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OF THE

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VOL. IV. 1848. PART I.

November 15th, 1848.—The session was, at the request of the Council of the Society, opened by the following Address from the President, Professor Oldham.

GENTLEMEN,

WE meet this evening, at the commencement of the eighteenth session of our Society, the first during which we assemble within the walls of our University; we meet under circumstances somewhat different from those under which we have hitherto assembled; with new prospects and with new hopes. It appeared, therefore, to your Council not undesirable that these circumstances should be briefly adverted to; that this change in our condition and prospects should be noted, and that the ground of these hopes should be placed before you; and on me, as President, has the duty necessarily devolved.

The Geological Society of Dublin was, as many here are no doubt aware, established in the year 1831, for the express object, as stated in the constitution of the Society, "of investigating the structure of the earth, and more particularly of Ireland," and it at once took a high position among the scientific bodies in this city. X We are not unwilling to believe that much of this rapid distinction

was due to the gratifying fact, that the Society when called into being, was presided over so ably during its first two years, by the then head of this University, whose name is so gratefully remembered by all who have traced the progress of knowledge and of education in Ireland, and whose presence among us was felt to be a guarantee amply sufficient that our efforts would be wisely and effectively directed to the advancement of our science, and to the improvements in its applications to the purposes of art. And we would gladly wish that some of the fame which sheds a halo round the memory of the late Provost, to whom the improvements in education are so deeply indebted, should be shared by this Society, as one of the means for that advance, which his sagacity foresaw, and his energy carried out.

With varying but still marked success, the Society continued its meetings for many years. It elicited many papers of great interest and value, relating to important points in geology, both abstract and descriptive; and our Journal may safely be referred to, as containing communications full of valuable matter to geologists in general, and more especially to those who would make the geology of Ireland their peculiar study. But in the history of every such Association there comes a period, when, losing the excitement of novelty, several, who at first, perhaps, eagerly joined in the project, become cold in their service, or leave its ranks—when some trifling cause, which at other times would never be thought of, is a sufficient excuse for many to change their plans—or when a cessation of personal intercourse leads to the abandonment of common pursuits; and to some such cause it is not improbable that we must attribute the difficulties in which the Society found itself placed about the year 1841, when its regular income becoming insufficient for the purposes to which it was applied, it became necessary to give up the rooms it tenanted. Previously to this a considerable sum had been expended in the purchase of such books of reference as were considered of essential importance, and very considerable progress had been made in the bringing together a series of rock and fossil specimens, such as would facilitate the study of our science, the extent of which will be seen by a reference to the catalogue published by the Society, at that time, and drawn up by Mr. M'Coy.

To any one acquainted with the working of public bodies, it will be quite needless to remark on the injurious effect which such a

step as a removal, and consequent abeyance of a Society, however temporary, must necessarily exert on its prospects; and your Council could not, therefore, feel any surprise, however much they must have regretted it, to find that in consequence the annual income of the Society was for a time very considerably diminished. By great exertions on their part, however, apartments were secured in an unoccupied portion of the Custom House, well adapted for the purposes of the Society, and your collections removed there. Gentlemen, I would be wanting in my duty, were I not here to express the debt of gratitude which the Society owe to one of their oldest and warmest supporters, Mr. Hutton, for the ready and liberal manner in which they were accommodated in his own house during this interregnum. These apartments being granted to the Society, free of expense, so long as the public service should not require them, the entire of your funds became applicable for the more legitimate objects of the Society; and I need only point to the annual reports of your Council, and to the Treasurer's accounts annexed thereto, to prove that those funds have been most effectively and economically applied. Your collections continued to increase in number and value—donations poured in rapidly—your library of books, charts, and maps was rapidly progressing also, and every thing seemed to promise to the Society a successful career; your museum was freely thrown open to the public on two days in the week, and every aid that it was in the power of the Society to give, was afforded to the student of geology, or the investigator of its applications.

Such was the progress of the Society from the time of its location in the Custom House, in 1842, until the summer of 1847. The painful visitation of that year must still be fresh in the recollection of all; and while your members were each anxiously engaged in their individual efforts for the relief of the distress which surrounded them, and so employed, that there seemed but little prospect that sufficient attention could be given to the pursuit of scientific inquiries, (for it is not when the mind is harrassed by anxiety, and the feelings strung by the emotions of pity and distress, that we can calmly devote ourselves to such pursuits;) and while, consequently, the progress of your Society seemed, for a time at least, and *indirectly*, to be seriously menaced, the same distress affected you more *directly* in another way. The very great increase

in the number of persons employed in those public departments more immediately engaged in the alleviation of the general distress, necessarily demanded increased and immediate accommodation; and your Council was therefore called upon, rather suddenly, to give up the rooms they occupied, those rooms being imperatively required for the public service. Gentlemen, having been at that time one of your Secretaries, I can therefore speak with some knowledge of the facts, and assure you that no proper exertions were spared by your President and Council to avert this injury, as far as in them *lay*; but I think I need only refer to the circumstances of the time to prove that this necessity for increased office accommodation did in reality exist on the part of the public departments. Finding it, therefore, vain to seek a continuance of those apartments, it became essential that your Council should determine what they would recommend to the Society to be done with the collections, and what steps should be adopted to secure the effective working of the Society for the future; and, after many and well matured deliberations, it was decided unanimously, that the recommendations submitted to a special meeting of the Society in December last, should be adopted. You are aware of the purport of those resolutions, and of their being unanimously confirmed by the Society at large. The officers of the Society were authorised, and proceeded to carry out these arrangements, and in consequence of them we now meet within the walls of the University, and under the sanction of its governing body, who most warmly seconded the views of your Council.

This change, however, gentlemen, appears to involve many more important considerations than a mere change of our abode, and it has not therefore been thought desirable to pass it over without notice.

At the time of the establishment of the Society, it was not until after much deliberation that it was determined to found a Museum in connexion with that body. Strong and influential opinions against the advisability of that course were forwarded to several of the members then anxiously engaged in framing the constitution of the Society—opinions derived from, and sanctioned by, the experience of similar associations in London and elsewhere. But after full consideration of all these reasons it was ultimately determined by the Society to commence a Museum, and I most fully concur in the

wisdom of that determination, under the circumstances. There was at that time in this city, no collection whatever available for the geological student—of simple minerals there did exist some collections, though not very usefully arranged for the student; but of geological, in its proper sense, there was literary none. Now, it was perfectly essential for the success of the Society, that such a collection should be accessible; and most wisely, therefore, did its members devote much of their attention to such an undertaking; and previously to its transfer to the University, a collection had been brought together and arranged, quite sufficient to enable the student of geology to acquire all the aid requisite in his studies. Again: more recently, when the applications of geology became of importance, the Society most wisely, (and most effectively too, considering the means at its disposal,) established a collection illustrative of those applications, and were thus the first, in this country, to found a Museum of economic geology.

But these necessities, I believe, would not have existed, were there other collections in this city available for these purposes; and had this been the case, it does appear to me that it would have been a misapplication of the funds of the Society, to have devoted any portion of them to the accumulation of specimens illustrative of such inquiries, when such collections were accessible elsewhere—and such, I believe, was also the feeling of your Council. It became, therefore, a special object for their consideration, whether, in the progress of time, circumstances had so changed, as to render any alteration in their arrangements desirable. Their experience had taught them practically the justice of the forewarnings they had received at their commencement, and they had felt that the reasons urged then against the establishment of a Museum were not without good foundation. Nor while they had been so anxiously devoting themselves to the spread of geological knowledge, had they been unmindful of the exertions made by other bodies in the same direction They hailed with sincere gratification the appointment in this University of a Professor of Geology in 1844, and the nomination to the chair of one who had so long and so sucessfully cultivated the science—they saw with peculiar pleasure the subsequent placing of the Museum here, under the charge of one of your Secretaries, knowing full well that the untiring zeal and unfailing exertions of its director would render that Museum worthy of the institution to

which it was attached, and of his own high and well earned reputation—and they perceived, and rejoiced too in the fact, that the collections of the Royal Dublin Society, under the charge of their able and deeply-read Professor, Dr, Scouler, were greatly increasing in extent and value—while, as regarded the applications of geology to practical purposes, it was with unmixed pleasure they watched the establishment by her Majesty's government, of a Museum of Practical Geology, under the immediate control of one of their own members, Sir Robert Kane, in which the objects which they had attempted with their limited means would be effectively and liberally carried out—while the extension of the Geological Survey of Ireland, in connexion with that of Great Britain, (thus securing an unity of principle in the execution of the work,) was an additional proof that public attention had been effectually aroused in this country to the value of such pursuits, and that however little they may have gained in a pecuniary point of view, still they had been instrumental in advancing the science, by increasing the number of those interested in it.

Carefully considering these facts, they thought it would be worse than useless for them to attempt, with their very limited resources, to fulfil duties which had been liberally undertaken by others with abundant means at their disposal; they, therefore, recommended that all your collections should be handed over to the University, satisfied that by the exertions already made by that body, a sufficient guarantee was afforded that these collections would be effectively and judiciously applied for the advancement of the science. They felt also in some degree honoured by having it in their power to make an acknowledgment of those important improvements; while at the same time they trusted it would prove an encouragement to their further extension.

In pursuance of this arrangement we meet this evening, gentlemen, within the walls of that University where most of us first imbibed our love of knowledge, where our most lasting associations were formed, and to which we look back as the source of our purest and highest enjoyments. We meet, too, under the roof of one who has so ably seconded and carried out the enlarged views of our first President; and who, through good report and evil report, has steadily advanced our views, and aided our intentions. We meet in a new abode, and under new auspices, with increased hopes

for the future, and increased pleasure in the retrospect of the past. It would be idle to attempt to conceal from ourselves the importance of such a change. To be thus admitted into connexion with the University, and to be acknowledged by the heads of that body, is an admission and acknowledgment not so much of us as a Society, as of the value and utility of the objects for the cultivation of which we are associated, and of those objects also in their highest and most important end, viz.—as a means and as a branch of education; and this consideration naturally suggests a few remarks on the real end and aim of our studies, and on the means which we can bring to bear on their improvement.

Probably the best, because the simplest, definition of geology, consists in the literal translation of the term itself, and we would thus define it—as the science of the earth, or the history of the earth, taking these words in their full and extended significations. It would be quite out of place here to detain you with any statement, however brief, of the successive phases through which this study has passed, or even to allude to the wild speculations of the earlier inquirers, in which geology was mixed up with the dreams of mythology, or fancies in cosmogony—speculations to which, however, we think too much blame has been attached, for from the then state of the collateral sciences it was impossible that any very sound advance could be made in geology. But there have been two prominent epochs in the history of our science, to which we may profitably allude for a few moments, inasmuch as the doctrines then propounded and received, have exerted, and continue to exert, an influence on the progress of our study—I allude to the times of Werner and Smith.

Long before Werner sent forth from Freiberg his system of geognosy, several valuable attempts at classification of the rocks of our earth had been made, and much information obtained; but it was reserved for him to propound a general theory regarding their distribution and classification, the principal features of which I need scarcely say, were the universal distribution of certain formations in a certain order, and the general aqueous origin of all rocks. It cannot be doubted that the classification adopted by him was a retrograde movement as far as scientific principles were concerned. His views were derived from a limited examination of a very limited district in Germany, and hastily and unphilosophically generalised

into a scheme asserted to be applicable to the world at large; and in this scheme he almost totally neglected all the information which had been already obtained as regarded fossils, Gifted, however, with a power of throwing a charm about his subject, which drew to him from every quarter eager and attentive pupils, investing those speculations with an ideal generality which they possessed not in fact; and in some degree masking the physical improbabilities of his hypothesis by his own peculiar acuteness of observation and power of methodising, he excited a similar earnestness in the students at Freiberg, and by their travels his views became rapidly spread, and maintained for a long time a supremacy among geologists. The notion of the aqueous origin of all rocks was at once and seriously contested, because there were few districts which did not afford proofs of the untenability of such an hypothesis; and the futility of trusting to mere mineralogical or lithological characters was also shown very soon; but to upset the most dangerous part of his scheme—that of the universality of the formations—was not so easy, for this required extended examinations in many districts, and in large areas. This notion, therefore, continued to exercise a most pernicious influence on the progress of the science—an influence, I regret to say, by no means exploded; for even in one of the most recent papers on descriptive geology published in Great Britain, we find the unconformability in area of two distinct groups of rocks (the old Red and Silurian) stated with all the prominence of italics, "as a most important conclusion," derived from extended examination—while in a proper view of the case it would have been indeed a most important conclusion, and one to be established only by careful examination, but never anticipated, were they really co-extensive. It is unquestionable, that much of the errors which such a scheme contains, arise from the appearances presented in an isolated and very restricted area being considered representative of those which are universal; and it is not improbable also, that had circumstances placed Werner in a district of a different character, his scheme might have been very materially modified.

The epoch of Smith and Cuvier was also marked by a rapid accession of knowledge in our science; and by the proposition of sounder and more generally applicable views, and the observations of Smith, which established the fact of successive groups of organized beings being found in, and confined to, successive groups of

strata, excited great and deserved attention; but while tending most essentially to advance our knowledge on the subject, appear to me to have exerted an injurious influence also, from which we have not as yet been altogether freed.

The interest which such laws gave to to the examination of the fossiliferous rocks was such as to excite to the study geologists of every country. The value of their aid as auxiliary to the inquiries of the geologist became so apparent, that he forgot they were valuable only as explained by the naturalist. The advantage of a knowledge of the remains of animals and plants found in rocks, as elucidating the structure and mode of formation of these rocks, was so apparent, that every geologist devoted himself to ascertaining this knowledge, forgetting at the same time, that the only means he possessed of acquiring it, was by a study of similar creatures now existing, and many, anxious to describe the fossils which they found, were led to do so without due knowledge, and trusting to mere external form as a distinction.

A new name was given to this so called *new* science, and Palæontology was looked upon, described, and stated to be (and even still is by many) a branch of geology. We have on more occasions than one before now, endeavoured to show the fallacy of this notion. There is, there can be, no *new* science of fossil remains. The only means we possess of knowing any thing whatever regarding the structures and habits of creatures found fossil, is by a knowledge of the structures and habits of creatures still living. The study of the one is only an extension and an essential part of the study of the other; the objects, the laws, the methods of investigation, which regulate the one, are the same as those which should regulate the other. The examination of a plant, and the deduction of just inferences from that examination, is as much the duty of the botanist, and of him alone, whether that plant was gathered this morning, or whether we find its remains in the rocks formed countless ages since. The investigation of the skeleton of an animal, or of the shelly covering of a mollusc, belongs to the zoologist and comparative anatomist, and to him alone, altogether independently of the locality where they may have been found.

And if in existing nature it may be fairly demanded, that he who will undertake to describe the habits and structures of existing animals, should himself examine into those habits, and investigate

that structure, and if the conclusions of him who will be content to take such information from others, and seek not to ascertain the circumstances peculiar to the existence of such creatures, but depend on external form alone—if, I say, the conclusions of such a man are justly reckoned as of little authority, how infinitely less confidence should be placed on the conclusions of those who, in the much more difficult task of unravelling the habits and structures of those organisms, which we only know from their remains, rest contented with examining the collections of others, and, regardless altogether of the many causes which may have produced variation of form, hasten to accumulate distinctions, and to string together catalogues, which, thus prepared, serve no other end than to confuse our knowledge.

We would not be understood as in this arguing against the collection and study of these organic remains. Of their extreme value we are satisfied; nay, we believe, that that value has hitherto been much, very much underrated, or at least very *erroneously* estimated: but we would in the very strongest terms protest against the idea which appears to have possessed the minds of many labourers in this field, that such a study can be undertaken without, or independently of, existing organisms; and we would assert, that no benefit whatever can arise, so far as the true end and aim of geology is concerned, from such examinations and such classifications, even of thousands of different forms.

Be they ever so multiplied, facts when isolated are but of little value. We want the power and the means of colligating them. We see not the causes or the circumstances which have contributed to the production of the phenomena; and we cannot, therefore, trace, or even attempt to trace, the consequences which must result from them. It is in this, as in every other physical science—indeed in every branch of knowledge, the connexion of cause and effect, (to use the terms ordinarily employed,) this intimate and necessary dependance of every existing phenomenon on previous ones, that we seek to know and to discover; and the moment that we cease to be able to refer phenomena to their causes, that moment our knowledge of them becomes barren of its effects, and comparatively useless.

In the study of organic remains, therefore, we must never cease to search into the conditions of their existence, the effects which a

change in these conditions may have produced, the duration of that change, whether temporary or not; and therefore, whether on the return of similar conditions, similar forms of life have not also returned. We must seek to discover the laws which governed their distribution—the centres from which they have spread—their maximum period and maximum places of development; and thus, and thus alone, can we hope to eliminate from them the full measure of that information which they are capable of affording; and thus, and thus alone, will the study of palæontology have contributed its due share to the progress of our knowledge. While at the same time it must always be borne in mind, that in such inquiries the physical evidence of the condition of the area must never be made to yield to conclusions derived from organic investigations alone. The phenomena of life are too complicated and too numerous ever to be placed in fair competition with the laws of matter, and in all cases where there appears an opposition in their testimony, natural history must be led by physics and chemistry, and the right of precedence here, as elsewhere, be given to the exacter sciences.

It is always a difficult task to alter the general opinion on any subject, however erroneous such opinion may be. Facts, when discovered for the first time, either appear to the observer to harmonize with, or to be discordant from, those already known; they are looked upon either as confirmatory of known laws, or else as apparently contradicting them; and thus it would seem a necessary consequence of the state of our knowledge, that we seek to explain them by a reference to facts which we consider as more known, because of more frequent occurrence. The observers themselves are supposed to be, and probably are, the best qualified to suggest the best explanation; and this explanation, thus given, is received and held on their authority; phenomena being thus, on their first discovery, attributed to laws with which perhaps they have no true relation, and so attributed, simply because we are not acquainted with their correlative phenomena, these laws continue to be supposed applicable to the facts, at least by the majority of persons, long after their inapplicability may have been proved. The tenacity with which so called "popular prejudices" are held, may furnish a familiar proof of the difficulty of removing from the public mind ideas which usage has made a part of early tuition. And it is to some influence of this kind, it is certain, that we owe the very inju-

rious effect which the once popular notion propounded by Werner, of universal formations occurring in all countries in the same definite order, long exerted on the investigations of geologists, and even still continues to exert.

Smith and Cuvier had taught them a safer and a surer guide to a knowledge of the successive phenomena which had occurred on the earth's surface, than the mere mineralogical examinations which Werner had inculcated, and yet they continued to apply to this new method of investigation the same laws, the same principles, which had been arbitrarily applied to the old one. The regularity and remarkable precision found by Smith to occur in the neighbourhood of Bath, and by Cuvier at Paris, was at once supposed, without the slightest investigation of the facts, to apply to all other districts; and the rocks of one country were sought to be *forced* into a parallelism or agreement with those of another. The truth announced—and cautiously announced—by Smith, that each group of beds was characterised by peculiar organic existences, not found in the beds above, nor in those below, was perfectly certain as regarded the district in which his examinations were carried on; but it ceased to be applicable—that is, applicable with the same distinctness or precision—to any other district where the conditions had been different. Because it was found in one limited area that it might safely be asserted, that rocks which contained the same fossils were of the same age, this proposition, perfectly true in that limited sense, was at once, though most illogically, asserted in a general sense. It was forgotten to be considered, that the existence of organized beings inevitably depends on a variety of conditions favourable or unfavourable to their continued life, and that, therefore, that existence may in one district be continued through a much longer or shorter period, accordingly as those conditions may prove of longer or shorter duration. The discovery of the value of fossils having shown the uselessness of mineral character alone as a means of classification, the study or observation of that character was entirely neglected, although it should have been remembered, that in most cases it is the only satisfactory evidence we possess of the physical circumstances of the area under examination at the period of the formation of the rocks.

Gradually, however, new and sounder views have taken their ground, and instead of searching after and recording facts, however

unconnected, or collecting fossils, merely for the sake of adding uncouth names to some useless catalogue, and then boasting of how many hundred species have been noticed, a more philosophical spirit of induction now reigns. The laws which influence the distribution of animals and plants at the present day are searched into; the effects of permanent alterations in the medium in which they exist, the mode of accumulation of given materials under given forces, and the modifications to which these are subject—these are all eagerly investigated; and by the application of the line and the measure, results are obtained hitherto unequalled for their accuracy.

To this end the labours of British geologists have in no small degree contributed, and the establishment of the Geological Society of London, with the express view of investigating and collecting facts, regardless of theory, was one of the most important steps. Recalled from the absurd and monstrous speculations of olden times, to the safer and more valuable induction of facts, its members, ably seconded by the geologists of France and Germany, have brought together an immense mass of evidence, and accumulated a surprising amount of information—evidence testified by so many unconnected observers from various countries, and whose prejudices were all so varied, and so opposed, and so entirely uncontradicted by any conflicting testimony, that the truths thus established become irresistible, and preclude for ever the possibility of theorists reverting to speculations of the ridiculous nature of those of the early investigators.

I have, however, little doubt, that this exclusive devotion to the investigation of facts, has itself had an injurious effect of another kind, viz.—that it has repressed all saliency and originality of thought, and given a new, and even more pernicious, direction to that tendency to speculate which is inherent in our nature. The impossibility of pleading ignorance of the facts, or of running counter to them, has led to hasty generalizations of those facts; and these generalizations, necessarily put forward by men of high and original stamp of mind, as great and comprehensive truths, are received and retained by others. Much yet remains to be done in the removal of such difficulties, and much has yet to be unlearned. It appears to me a false and dangerous philosophy, though sanctioned by many of the high names in our science, which seeks to separate the observer from the investigator, to limit some to "the

bag and the hammer," while others presumptuously arrogate to themselves the sole authority to reason on the facts. The eye of the mind must be educated and exercised as well as the eye of sense. It is unquestionably true, that without this exercise of our reason in speculating on the causes of what is before us, we may see what others have seen before, and thus confirm knowledge already possessed—but if our observations are to tend in the slightest degree to advance the bounds of that knowledge, or correct its errors, we must be fully aware of the supposed causes of these phenomena, and make our observations the test of their truth. We must know why, as well as what, to observe.

And not the least advantage resulting from such studies, considered as a means of education, consists in such habits of observation, which they necessarily produce, together with their inevitable consequences, viz.—that they call into being, and provoke the exercise of a process of self-education, without which no man is well taught. For although in this, as in every other physical science, where the great means of acquiring knowledge is by observation—although, I say, much must be received on the authority of others, unless we would have the human mind remain stationary, and allow the accumulated stores of information of one man, or one generation of men, to be lost to another, still each for himself must go over these observations—each must trace the steps in the reasonings founded on them, and stamp those reasonings with the impress of his own individuality—each must observe, each must compare, each must discover for himself. And this process seems unavoidable, because it is to the mass of learners impossible to convey by the description of others, however lucid they may be, a clear conception of material forms and arrangements, which must be seen to be understood. The students are thus compelled to go to the great book of the world itself for their information, if they wish that information to be accurate; they are compelled, to use the graphic terms of Leonardo da Vinci, to be "the children of nature, and not her grandchildren," and to compare the records of others with that original record which she has every where placed before their eyes—the writings of men with "God's epistle to mankind," the earth. And we may safely affirm, that such habits of observation and comparison once produced will continue to be exercised. I think it is Savage Landor who eloquently says, that "nature

cometh not into the market-place with sound of trumpet to proclaim her truths." They must be sought after patiently and carefully. We must devote ourselves to her service, if we would be honoured by her confidence. "Rerum natura," says Seneca, "sacra sua non simul tradit * * * illa arcana non promiscue nec omnibus patent; reducta et in intimo sacrario clausa sunt." * * * "servat, quod ostendat revisentibus."*

In the prosecution of such inquiries also, new methods of reasoning and new modes of research are called into action. The questions to be solved are not of our own imagining, they are ready prepared to our hands. We cannot start by our own suppositions, and setting down definitions demonstrate identities as determined by a reference to such definitions. We must compare, we must determine resemblances by a reference to types. and establish a similarity in effects by their analogy to known results of known causes: and hence it is the cultivator of the natural sciences alone who fully appreciates the value of Newton's rule of philosophizing—"Effectuum naturalium ejusdem generis eædem sunt causæ"—because it is he alone whose mind is trained to the habitual determination of the question, as to whether the effects be really of the same kind—"*ejusdem generis.*"

In this power of reasoning from analogy, in the necessity of estimating degrees of probability, and balancing varying amounts of evidence, and in the *educing* of the habits of thought consequent thereon, consists another and a very striking excellence of the natural history sciences as a branch of education. It was from a neglect of the proper exercise of such power, that the injurious effects of the doctrines propounded by Werner and Smith arose, to which we have already alluded.

And if in the study of the works of those authors, whose abilities have shed a lustre on the epochs in which they lived, we feel our emotions kindled, our imaginations delighted, our tastes matured, and our power over the complicated, but ever necessary, machinery of language increased—and if, by the higher sciences, our intellects are cultivated, and the dominion of our thoughts over the phenomena of the past and the future extended, while a spirit of rigorous exactitude is engendered, and an habitual demand for the demonstration

* Quest. Nat. vii. 30.

of a statement before it be admitted as a truth—and if in the investigation of ourselves as individuals, and as portions of the social system, we are led to habits of patient thought and important analysis, there yet remains, we are satisfied, a blank, which the natural history sciences alone are fully competent to fill; and we think that they will prove of essential service in the cause of education, by calling into active and continuous operation habits of thought, and educing powers of mind, for the exercise of which the other branches of an University education offer no sufficient field.

In thus alluding to the value which we believe inherent in the natural sciences as a branch or means of education we cannot but refer with extreme pleasure, to the recent establishment in the University of Cambridge of a Natural History Tripos, by which the honours assigned for the successful cultivation of these studies are placed on the same footing as those long awarded to classics and the exact sciences. This acknowledgment by such a body, and in such a way, of the utility of these studies, as a branch of education, cannot fail to operate most advantageously for their promotion.

But if this be really the case, and that our pursuits are truly of advantage, as parts of an educational system, it seems at once to suggest itself, that meeting now within the walls of a University, so long and so proudly pre-eminent for the freedom with which its educational advantages have been thrown open to all who desire to avail themselves of them, that we should view ourselves, even more than we have been wont to do, as an educational body, and as devoted as much to the improvement of others, as to the advancement of our own information. Let us not forget that we are all fellow-labourers in the great search after truth, fellow-pupils in the school of nature, fellow-students of that first book—the world; each ready and anxious to communicate to others any knowledge we may ourselves possess—each willing, and I trust, most anxious, to learn from others all that they can communicate. We may not, perhaps, be able to boast of many of those whom Bacon, in his philosophical fiction,* calls "merchants of light;" we cannot in Dublin, expect or anticipate that influx of communications on foreign geology which forms such a large proportion of the business of the Geological Society of London; but we have our "depredators," our "pioneers," our

* *Novis Atalantis.*—Bacon's Works, Vol. 4..

"lamps," and our "interpreters of nature." We can point to our Journal for the communications of many of these already, and we do hope for a continuance and increase of the number. And I cannot but express the hopes which have animated your Council, that we shall find a large accession of strength within these walls, and may justly anticipate a great increase in our knowledge on those higher points of speculative geology, to which the powers of the mathematician and physicist can alone be efficiently applied.

I must, however, be allowed a word of caution on such points, eagerly hoping, as I do, that the Society may soon congratulate itself on the high mathematical powers of some of its members being brought to bear on the investigation of its questions. I may be permitted to suggest, that in all such inquiries, the problem to be solved must be accurately ascertained, before its solution can be usefully given. I am led to allude to this, because geologists have been deprived of almost all the advantages which would have resulted from the contributions to physical geology, which mathematicians have already brought forward, by the simple but fundamental error, that the problem has been mistaken, and consequently the solution given, however accurate, is inapplicable to the purposes for which it was intended.

I have purposely avoided alluding to any of the *enjoyments* to be derived from such pursuits, although I keenly feel them myself, and believe the heart must be dead indeed to all such emotions which would not; but these enjoyments are not so much advantages resulting from the study of natural history, as inducements to that study; nor would I detain you with even an allusion to the many important ways in which our science addresses itself to the favour of the utilitarian, by the numerous practical results of great benefit which arise from its application. We have no fears that these practical applications of geology will ever be underrated or neglected in this University, which may claim the honour of being among the earliest to establish a distinct school for applied science, to which the chair of Geology is more immediately attached. And while we would on all occasions unite the endeavour to rise through successive steps of reasoning to the attainment of principles, with the limiting of these principles to particular operations—"ascendendo ad axiomata, descendendo ad opera"—we yet believe that the order in which these terms have been placed by the great author of inductive philosophy is the true one, and that these prin-

ciples must first be carefully ascertained, before they can be satisfactorily applied.

Much yet remains to be done, and done in so many ways that there is not one among us who cannot contribute. So extended is the circuit of our inquiries that every step we take, we are made to feel the necessity for the cordial aid and sympathy of others. To few individuals indeed is it given to possess that extent of knowledge which would enable them to range through all parts of our science; and even had this Society not existed, it would now be necessary to unite the efforts of many for the solution of our problems.

In looking back on our past career, if we have failed in ought let the failure be only a warning to avoid its cause, and overcome its difficulty: if we have succeeded, let our success be but an encouragement to further exertion. Remember the words of Demosthenes—

*ὃ γάρ εστι χείριστον αὐτῶν ἐκ τοῦ παρεληλυθότος χρόνου, τοῦτο πρὸς τὰ μέλλοντα βέλτιστον ὑπάρχει. ἐπείτοι εἰ πάνθ' ἃ προσῆκε πραττόντων, οὕτωσ εἶχεν' οὐδ' ἂν ἐλπις ἦν αὐτὰ βελτίω γενέσθαι**

But have we thus done our utmost? I fear not, and there is one mode in which many who perhaps may never have the opportunity of contributing original communications to our Society, may yet most materially aid the progress of others. I mean by additions to our library. And if a list of deficiencies, and of desirable additions, be laid before the Society, I will not think that our love has been so chilled, that there will not be found many who will be glad to have placed here some contribution which may link their name permanently with our progress.

Such, gentlemen, are our prospects for the coming session, and I hope most sincerely that at its close I shall be enabled to congratulate you on the fulfilment of these hopes, satisfied that any cause which may prevent such an issue must be one more general in its operations than as affecting us alone. So long since as 1831, the period of our first formation, the able professor of geology in Cambridge, speaking from the chair of the Geological Society of London, in words peculiarly applicable at present, and which seem almost prophetic, eloquently said—" Our studies have no part in those passions " by which mankind are held asunder—the boundaries of tribes and " nations are blotted out from our maps—the latest revolutions we

* Demos. Phill. 1.

"treat of, are anterior to the record of our race, and compared "with the monuments which we decipher, all the works of man's "hands vanish out of sight. If we have advanced with a vigorous "step for the last fifteen years, it has been during the peace of the "civilised world. The foundations on which we build are so "widely spread, that we require nothing less than a free range "through all the kingdoms of the earth—and if anything should "occur to cloud our prospects or retard our progress, it must be "accompanied by some moral plague which will desolate the face of "Europe. Against the visitation of such a calamity every man "whom I now address will join with me in heartfelt aspirations."

Permit me to add a word before concluding—to myself personally the meetings of the Geological Society have been sources of unmixed pleasure. I have been deeply interested at the time—I can recall the hours spent with you with still deeper enjoyment—the frank and cordial kindness I have experienced—the manly and ingenuous friendships I have formed, and the warm support I have invariably met with here, originating in the congeniality of common pursuits, have associated these meetings, in my mind at least, with all that is kindly in feeling and honourable in principle, and I would express my sincere hope, that I may be enabled to continue them in the same spirit. Controversies, no doubt, arise, and these are inseparable from the ever progressive character of the study; and perhaps there is no stronger proof of the vigorous and healthy manhood of our science than the fearless courage with which every statement is canvassed, and its evidence investigated, before it is allowed to take its place beside truths already established; yet these discussions, conducted as they have been with good feeling and mutual respect, snap no tie of friendship, and chill not the warmth of our intercourse. Let private differences here give way to the common good: no envious rivalry, but that generous and benevolent impulse of honourable emulation which prompts while it enables mutual assistance: no seeking after victory to the neglect of truth. Let our meetings continue to be distinguished by that freedom of discussion and freedom of intercourse—that unflinching expression of opinion, coupled with an equally unflinching kindliness of feeling, which have hitherto marked them; and I feel assured that they will prove to others, as they have done to myself, the source of warm personal attachments, and of healthy intellectual enjoyments.

November 15th, 1848.—"On Oldhamia, a new genus of Silurian fossils," by EDWARD FORBES, Esq., F.R.S., F.L.S., Professor of Botany, King's College, London, and Palæontologist to the Geological Survey.

THE rarity of organic remains in the Cambrian, or oldest portion of the silurian strata, renders every addition to its fauna of great palæontological interest. The earliest fossils which have yet been discovered seem to be certain plant-like impressions, or casts discovered by Professor Oldham, at Bray-head, in Wicklow, and referred to by him in his communication to this Society in 1844. These bodies present the appearance in most specimens of a central filiform axis, with fasciculi of short radiating branches proceeding from its sides at regular intervals, or of bundles of such filiform rays without an axis. A close examination of them shows, that each branch is formed of a series of articulations, marking the positions of minute cells. The entire body presents a striking resemblance to the arrangement of parts in certain zoophytes, as in *Sertularia cupressina*, but are also consistent with those exhibited in many BRYOZOA, as in *Gemellaria* and *Cellaria*, an alliance more in accordance with the minute structure. I propose the name *Oldhamia* for these remarkable fossils, in honour of their discoverer, who has in them made us acquainted with what in all probability is a group of ascidian zoophytes, or rather compound tunicated molluscs, in stratified rocks of very early date, and has thus furnished an additional, and important fact in contradiction of the crude notion, that the earliest forms of animals are the most rudimentary.

"On the maps and sections of the County of Wicklow, published by the Geological Survey," by PROFESSOR OLDHAM, F.R.S., President of the Society, and Director of the Geological Survey of Ireland.

THE President explained in detail the geological map of the County of Wicklow, just published, entering on the classification of the rocks, their subdivisions and mineral character, and the method of constructing the sections; and detailed the principal points in which the researches of the officers of the Geological Survey had led to conclusions different from those previously published.

The details of these researches will be published in connexion with the Geological Survey of Ireland.

December 13th, 1848.—"Proposal for the general adoption of a new and uniform principle for laying down Geological Sections," by ROBERT MALLET, Esq. C.E., M.R.I.A., &c.

ON examining the sections accompanying the many geological memoirs which now occupy this field of scientific literature, it is in vain that we look for any general or uniform principle upon which they have been laid down. In each case the author appears usually to have chosen some arbitrary line of section, for the most part across the line of strike, more or less obliquely, and giving his preference chiefly to the localities where the dips are largest and most precipitous, and the succession of strata the most complex and involved.

No reference to any particular azimuth has been deemed of the least import; nay more, it has seldom been deemed indispensable, that the line of section should be taken in one right line; and instances may be quoted in abundance of valuable memoirs by geologists of acknowledged standing, in which sections are projected out into one plane from a sinuous line, meandering over the country in various azimuths, whose directions have been chosen, wherever the author fancied would give the "most illustrative section" of his particular views; sometimes apparently through mere caprice, and most commonly more with reference to producing a striking, and gaudy display of colour and form, when attached to the wall of the Society or lecture-room, than with a view to present the best and fairest anatomy of the country considered as laid open to the eye.

The result is, that the existing sections, accompanying memoirs and reports, are of extremely limited value—of none, if the time and labour bestowed on their production be considered; and from their isolated existence, and arbitrary choice of direction, they admit of no inference whatever being drawn from them, as to the nature of any other section of the same country, at a distance, (whether parallel or across,) which may not be actually given. Nor, again, do the two or three sections as ordinarily given, enable any correct notion to be formed usually, as to the physical features of the country proposed to be described.

Thus for example, a section across Devonshire, taken nearly north and south, though giving a "highly illustrative" view, per-

haps, of the succession of strata would, alone, give a most erroneous notion of the physical character of the surface of that county, and no just indications of the class or degree of forces, that were concerned in its formation; but if in addition to this section, we examine another, taken from Landsend, say to Shepton-mallet, nearly at right angles to the former, the imagination becomes at once informed as to the true physical character of the three adjacent counties. We see at a glance, that the billowy contour, which the north and south section of Devon presents, is no true representation of the general character of the surface of the county. We look to the east and west section, and we find the sharp configuration of Cornwall gradually rounding into the more subdued hilly forms of Devon. And as we pass again into Somerset, we find formations of finer materials have impressed on its surface the peculiarity to which its scenery is due—rich flat alluvial valleys, level as seas, with long meandering hilly promontories projecting into them, and dividing them from each other, like forested continents, with waving seas of grain between. Yet north and south sections only, of each of the three counties, might be in physical contour very much alike.

To take a larger example. If we suppose a geologist of our day possessed of materials for a map of south America, he would probably choose for his "most illustrative" sections, one right along the chain of the Cordillera; and, perhaps, one or two more, chosen at random from this or that spot to some other, where the interval contained some point which he deemed needed enforcement or "illustration." His sections presenting a tremendous jumble of "anticlinals," and enormous disturbances, many of which, though close together in section, might have very little real connexion, and depending for very much below the surface line on inference, or too often on fancy, would convey no real or just notion of the physical surface of the continent; nor, indeed, convey any information whatever, beyond a confused and, perhaps, often erroneous statement of the succession of strata.

We shall recur, however, to this example, to show how different would be the result, if his sections were sufficient in number, and chosen in right directions.

The proper uses of geological sections may probably be comprised under three heads:—

1. To give the physical features of the country correctly; and,

thus, by addressing the educated imagination through the eye, to enable distinct ideas to be formed, as to the sort and degree of the forces concerned in its conformation and configuration.

2. To give a true picture of the succession of strata, and their true relations at distant points of surface; and as far in depth as may be *certainly inferred*, but no further.

3. To supply economic information, such as relates to coal measures and mines—mass and character of loose surface materials, and their relation to the subjacent rock, or those from which they may have been formed—quarries, agriculture, drainage, &c.

I presume it will not be contended that these conditions are even imperfectly fulfilled by the present order of geological sections. My object, then, is to propose a new method which shall fulfil these conditions and others besides, and which shall, if adopted generally by geologists, confer upon this part of our science, that uniformity and mathematical character, which its present and prospective positions, and its intimate relations with exact science already warrant.

My proposition is, that in future all geological sections, whether those belonging to private memoirs, or to great connected works, as in national surveys, should be laid down and published, under the following conditions, viz:—

1. That all geological sections shall be laid down in the planes of great circles, passing through lines, running due north and south, or due east and west; in other words, in latitude and in longitude.

2. That where *several* sections of a given district are capable of being had, (and they are always desirable) they shall be laid down parallel to each other, and at equal distances apart, whether running north and south, or east and west.

3. That all sections be plotted to equal horizontal and vertical scales, and all referred to the half-tide level, for datum line.

Where several such sections, both north and south, and east and west are laid down, they become in fact a sectio-planographic model of the district referred to. They may be conveniently laid down upon square-ruled paper, and may be drawn parallel to each other, with their respective base or datum lines, placed at distances equal to those of the planes of section, so that in most instances, the two sets of sections at right angles may mutually intersect

without confusion, and be laid down upon the same sheet, whose surface may also represent a skeleton map of the surface of the country, i.e., both sets of sections may be laid down on a copy of the uncoloured map.

From two such sets of parallel, normal sections, it will be obvious to any geometer, that any number of intermediate sections, in any required azimuths, may be inferred by well known methods, and laid down, as required, on separate sheets; and it is also plain, that instrumental means may be devised for mechanically transferring such intermediate sections, from the normal ones, and plotting them. So that when once the requisite number of north and south, and of east and west parallel sections are obtained, the whole district in question is laid open, and may be, as it were, further anatomized, in whatever directions, not only the original geological explorer may then deem "most illustrative," either of the country or of his particular views, but also in whatever directions future observers or critics may require, either for purposes of the field or of the closet, without again having to refer to anything beyond the normal sections and surface map.

I propose that north and south, and east and west, sections should collectively be called *normal sections;* and as very frequent reference will be requisite to the respective directions of sections in description, I would further briefly call every north and south section, or one in latitude, a *makrotome,* every east and west section or one in longitude, an *eurutome,* and every intermediate or inferred section in some other azimuth, a *mesotome.* Where an extended and connected survey of a kingdom is made, and such normal sections are adopted, their multiplication will render an easy mode of reference to any one, without tediously naming the places of its extremities, desirable. For this I propose, that the normal sections on the meridians of latitude and longitude, should be taken as origins, and called *principal normal sections;* and that those normal sections occurring between such be referred to by number. Thus, a principal normal section, east and west, on the meridian of longitude, passing through latitude, 52°, for example, will be the eurutome 52°, and all made parallel, and north of it, between it, and the eurutome of 53° will be designated as Eu. 1, Eu. 2, Eu. 3, &c., and in the same way for makrotomes; while the extremities and directions of mesotomes, may be at once indicated by referring

to the points of intersection of eurutomes and makrotomes, between which they are drawn as extremes, thus—

52° Eu. 1. × 7° Ma. 2. . . . . . . 53° Eu. 5 × 7° Ma. 20.

would express a section running diagonally through a portion of the south of Ireland, in a direction north-west and south-east, and whose position might be found upon any map.

For much smaller areas of survey, perhaps this notation might be a little modified.

Let me repeat here, however, that my proposed method comprises two distinct propositions, capable of being adopted separately or together. The one, *that all geological sections be made in great circles of latitude or longitude;* the other, *that many such equidistant parallel sections be given* as an important instrument of record in all cases.

It remains for me to add a few words in illustration of some of the advantages which I conceive geology must derive from the adoption of this method.

In glancing at a chart of the world, or at the surface of a terrestrial globe—however the eye at first be distracted by the utter irregularity of outline, the apparent confusion of surface and of all things thereon—we soon begin to perceive that all this complicated mass of seeming accident has nevertheless distinct relations to, and has been in fact formed by the great cosmical forces, acting upon, and in, the globe—that the globe itself has a perfect symmetry; that the great agencies of light, heat, electricity, magnetism, act symmetrically upon it, that is to say, with exact relations to revolution in, and plane of, orbit, and to its rotation and axis. Advancing one step we see the tides, winds, ocean-currents, climates, seasons, dependant upon the former, less apparently symmetrical, because involved mutually and in more multiplied conditions. And again advancing, we can perceive, although, we are as yet unable to trace fully, that the shapes, sizes, and bulk of continents and islands—the boundaries of land and sea—the lengths and directions of river courses—the existence of inland lakes and seas—of parched deserts—of rainless regions—of those of ever-dripping clouds—of thick-ribbed ice—of heat without a shadow—are still dependant upon these few great ruling symmetric forces; or in a word, that every form and phenomenon, which we are capable of observing upon our planet, whether

great or small—in time past or present—upon the earth's surface or below it—and however apparently paroxysmal or irregular—have reference in position, in extent, and in degree, to those great symmetric forces, which actuate the vast machine. If, then, geology aim at ultimately building up, from the ordination of these materials, a true cosmology, a real history of our planet—and to such unquestionably it tends, however feeble may have been our past approaches—it is plain that all our records of terrestrial conditions, all our surveys and sections, should properly keep in as close connection as possible with that *relation of symmetry, which is the condition of the forces upon which physical geology rests.*

Sections, therefore, in great circles of latitude and longitude, are *truly* normal sections, because *the only* sections which are really normal to the great ultimate powers of our earth—and as truly normal, whether only a yard in length, or girding the world.

When, hereafter, such sections shall be extended over vast spaces, it is difficult now to foresee the value and extent of the knowledge which they must convey through the eye; when they shall connect themselves over continents, with climate, temperature, and seasons, past and present, and through these, with all the relations of organic life—when they shall be sufficiently extended, to connect in one view, and enable the imagination to apprehend—which it must do before the reason can comprehend—the relations between the interior structure of our globe, with the forces acting upon its depths from without, and the structure and physical character of its crust, and the beings which inhabit it.

Let us recur to our example of South America, and assume sections, cutting it into parallel strips of a few miles wide, both north and south, and east and west. We already know enough to see with what interest we might observe in the makrotomes, the long prevailing swelling outline of the land—the great river courses—the deep depressions—the sudden uprearing of the serrated crests of the Andes; and in the eurutomes, as the eye traversed over them, from south to north, we should see the rocky land abruptly plunging into the oceans on either hand, but soon stretching out on the right into the elevated mighty table land of the Pampas, with the crests of the Cordillera, ramparting the Pacific, and the long sloping plains to the east that connect the Pampas with the Atlantic; such would be the first glance, but who shall set a limit to the amount of

physical information, which such a set of sections would convey, when the rocks below, in their relations of position, magnitude and nature were laid open to the eye, in direct connection with all the forces and conditions of the surface; what might we not gather at a look from such a picture?

Oneness and largeness of view are essentials to grasping the primal ideas of formative forces—the hypotheses, if not the theories, upon which geology depends. The want of these has at all times, but most strikingly in the epoch of Werner, retarded its progress. Of late a great advance has been made in the right direction by the publication of physical atlasses by Berghaus, Johnston, and others. These, however, do not meet the peculiar wants of geology, and with much desire to avoid that sanguine view which always follows a new thought, I cannot avoid the belief, that the extension of sections such as I now propose, would be found *an organon*, a machine of discovery in physical geology, such as the indeterminate calculus has been in its application to exact science.

Contoured maps have already been proposed; and in some places executed as aids to geological investigation. Without denying their utility, I cannot admit that they are any substitute for these sections; they give no connexion between the surface features and what is below; nor do they lead the mind through the eye to connect the formation, and configuration of the land, with the forces which have moulded, and which are acting upon it, and with its biological relations: for example, what information can a contoured geological map give of the relation at various points over a large area, between the nature and depth of loose superficial deposits, and the sort and positions of the rocky formations below, or of both, with the past and present forces which have ground down and distributed the former. But, again, contours can scarcely be extended beyond the land, yet it would be of great value that all geological sections should be produced as far as possible under the sea. How vast a proportion of the whole surface of our globe is hidden by the ocean; yet in it, and especially round our shores, the great and ceaseless elaboration goes on, by which new lands are formed, and the earth, which has "waxed old as doth a garment," is "changed as a vesture," and again fitted for the use of man. The mere outline of sea-bottom, if laid down according to the preceding plan, as far as soundings extend, would, in connexion

with the sectional geology of the adjacent land, and with the known tidal currents, give much new and valuable information; most so, if specimens of the sea-bottom dredged up at many known points were examined externally and chemically.

But one instance of such sea-bottom sections has met my eye. It is the chart of the German ocean given in Mr. Robert Stevenson's account of the Bell-rock Light-house, in which, with that intuition of symmetry, which belongs to the eye of the Engineer, he has made every section, in great circles of longitude; and, although the sections are not numerous, yet the chart conveys to the eye a clear notion of the aqueous forces that have conspired to produce the singular sea-bottom between the coasts of Scotland and Norway, England, Holland, and Denmark. In such sea sections, the half-tide level, of course, should become the datum, so that the sea surface should coincide in level with the base or datum line of the land sections.

Had this paper not already extended to too great length, I might proceed to show the value as economic instruments, which the mapping our own countries by such geological sections would give. Of what use, to coal-winning, quarrying, and mining, they would be —not only in opening to the eye the very bowels of the land, and laying bare the secret places of its treasures, but in showing the probable extents of subterraneous water sources; the directions of their outpourings and the best means of diverting them from the working below, or bringing them in springs and wells to the surface for use.

Of what value to the agriculturist in showing him the magazines of ancient rock, from which his soils have been transported— where these are fertile—where barren, and why; the direction and capability of local drainage, and its relations to the natural water-sheds of the land. But these and other such points I must leave to the sagacity of geologists, and conclude with but one more remark.

Actual models, geologically coloured, have been sometimes recommended as the best representations of districts.

To models belongs one defect, which they have in common with all geological maps. The actual surface of the land everywhere consists, partly of solid earth-fast rock—the skeleton, so to speak, of our mother earth; the other of masses of loose material, laying

scattered over it here and there—which, like clothing with flesh, rounds and smooths the outline of our landscape.

Now so far, no principle whatever appears to have been fixed by geologists, as to whether in any given map, they shall represent the subjacent rock formations only, over the whole surface, or the loose superficial deposits only, or how much of either; and, accordingly, most geological maps present a very puzzling mixture of loose *transported* materials, shown as the formation of the surface in one place, and fixed, or non-transported rock, at others. For example, if the actual surface materials be adopted, as those most proper to be mapped, and it is difficult to see any principle upon which any other choice has been made; then a geological map of Ireland would present little more than post tertiary gravels and peat; but its actual maps have partly shown these, and partly shown the rock below them, leaving both sides of the subject incomplete. Both should be shown, if possible, because both have intimate connexions, and are of scientific importance as well as of economic value; but neither map nor model can by possibility compass this —and while geologists would certainly make an advance towards a principle, by either giving us in their maps, the surface or the formative rock—either giving us the "rock or the rubble," and not sometimes the one, and sometimes the other; the greatest advance would be to construct our geological charts, so as to show both —and this condition, the system of parallel normal sections which I propose, can completely fulfil, as is obvious without further enlargement.

P.S.—Since this paper has been written, I have been favoured by a note from Professor Oldham, enclosing me a sheet of the Geological Survey of County Wicklow, upon which, in accordance with my suggestion made at our last meeting, (November 1848,) he has caused some normal sections to be drawn in. These, although further apart than they might have been, had there been more time for adding to their number, fully show the practicability and value of maps having both systems of normal sections laid down upon one sheet, and mutually intersecting. I cannot avoid congratulating my friend, Professor Oldham, upon thus being the first geologist to adopt, (with his usual zeal for improvement,) a system which I hope all geologists will accept, and extend the use of universally.

December 13th, 1848.—"On the Silurian fossils collected by the Geological Survey of Ireland, at Portrane, Co. of Dublin," by EDWARD FORBES, F.R.S., &c. Professor of Botany in King's College, London, and Palæontologist to the Geological Survey.

THE author communicated to the Society last session his observations on the silurian fossils of the Chair of Kildare, and shewed how the beds in which they were found were of a lower silurian age, and the equivalents of the "Bala beds" in Wales. By this determination, a base line for the Irish silurian strata was obtained palæontologically, and a great step gained towards their comparison with similar beds in the sister country. Since that time, considerable collections have been made at Portrane, and an examination of them has confirmed their identity with the Kildare beds, and the conclusions formerly inferred concerning the age of the latter. The published lists of Portrane species, given in Mr. Griffith's synopsis, drawn up by Mr. M'Coy, includes sixteen forms, one-half of which are corals, and the remainder are brachiopoda. A provisional examination of the Survey collections has yielded at least as many as seventy-seven, amongst which are twenty-three trilobites, ten gasteropods, four lamellibranchiata, and twenty brachiopoda. Several of these are new, and some of them very remarkable; more than forty of them are identical with species from the Chair of Kildare, including many of the most characteristic, as *Illænus Bowmanni*, very plentiful; *Sphærexochus calvus;* Spirifer *biforatus*, *insularis*, and *monilifer; Leptæna, sericea*, *quinquecostata*, and *depressa; Naticopsis concinna; Turbo rupestris;* and *Orthoceras gregarium.* Some other remarkable species are identical with characteristic forms from the silurians of Tyrone. The Portrane beds are locally peculiar for the quantities of corals they contain, and for the presence of *Trinuclei* in their limestones. These local peculiarities are often striking in beds equivalent to the Bala limestones.

January 10th, 1849.—" On the Cuttings exposed on the line of the Dublin and Belfast Junction Railway, by GEORGE V. DU NOYER, Esq. Geological Survey of Ireland.

THE sections which this evening I have the honour to submit to the Society, at the request of Professor Oldham, our President, and Director of the Geological Survey of Ireland, represent portions of the line of railway extending from Drogheda to Newry, termed the Belfast Junction, and include a distance of about eleven miles, commencing at Dromiskin, and terminating near Jonesborough-road, about six miles north of Dundalk.

Before calling your attention to the most interesting part of this section, which occurs at Faughart, north of Dundalk, I must offer some brief remarks on the cuttings north of Dromiskin. Here we observe a bed of dark purple vesicular trap, variable in thickness, which appears to cut in a horizontal manner through the green, gritty, and silty slates of the old silurian system. The trap, besides containing large included masses of pure grey carbonate of lime, abounds with minerals—those most prevalent being quartz, calcedony, carbonate of lime in geodes, and cubical iron pyrites. The slates in junction with it are changed to a kind of porcelain, and otherwise rendered hard and splintery. Again, about one mile nearer Dundalk, we find a good example of the power possessed by the former drift action, whether it was water, mud, or ice, or all three combined, to move slightly large and extensive masses of slate from the surface of the subjacent and nearly vertical rock.

Passing Dundalk, we find a cutting of about five hundred feet beyond Forkhill-road, through the green gritty slates and red and green shales of the system alluded to; and here we observe three cutting dykes of dark bronzy purple, hornblendic and micaceous trap. The thickness of these dykes is consecutively five feet, one foot, and four feet. In two instances their strike corresponds with that of the slates. In the third example the dyke cuts obliquely through them at an angle of about five degrees.

These are the only facts worth recording in the district over which we have passed; and I shall now attempt to describe those singular cuttings at Faughart. At the old road to Newry these cuttings commence, and extend northwards for the distance of 2,150 feet. The section at first exposes old silurian green gritty slates, and

green and purple shales, which are all more or less contorted and confused for the distance of two hundred and fifteen feet, when a break occurs, and we get to hard greenish slates, observable for the distance of two hundred and twenty feet, having an average dip N.N.W., the direction of the rails being forty degrees E. of N. and W. of S. In the centre of this mass, and running through it, we find a dyke of fine-grained, dark-coloured trap, three feet thick, in places resting on the edges of the slates, at others on their uneven surfaces. On the west side of the cutting this trapdyke is traceable for the distance of eighty feet, with a strike N. and S., at a variable angle of inclination to the E. and W., the slates in contact with it having undergone a certain amount of hardening.

We find the green and red slates appearing in small patches north of this, for the distance of three hundred feet, and, before we lose them, they dip S. 80°, thus appearing to form a synclinal. I should remark, that where we lose the slates they become of a dark-red claret colour, and the exact spot where they disappear is not seen; they probably are cut off by a considerable fault. In the distance of a few yards we meet a singular bed or mass of light grey limestone nodular conglomerate, enclosed in dark-red purple friable shale, portions of which adhering to the nodules cause them externally to resemble it in colour. What this conglomerate is I am unable to say. The section on the railway affords no data to determine its position or name, and my examination did not extend to much of the surrounding country.

We can trace this mass for thirty feet, and above, and apparently resting on it at a low angle, are soft dark-red shales, and coarse-grained felspathic dark-red grits of what appears, from its lithological character, to be old red sandstone.

The succeeding one thousand feet of the section is occupied by this sandstone, which, throughout the entire distance, is traversed in every direction by large and small masses of trap of different ages, forming vertical cutting dykes as well as horizontal, and I think contemporaneous beds or flakes. As these are of much interest they merit a description in detail.

At Faughart Farm Road-Bridge, where the sandstone first appears dipping E. and S. of E., at a maximum angle of about twenty degrees, we observe interstratified with it a bed of dark purplish green and fine-grained splintery trap, six feet thick, resting on a

thin seam of brown earth. This, in connexion with the fact of the trap being dislocated by the same faults which displace the sandstone, disposes me to regard it as contemporaneous with the latter, and thus, in the following description, I venture to designate it by the term, "old trap bed."

Passing Faughart Bridge, and included in the short distance of one hundred and four feet, we observe seven distinct breaks in the sandstone, which likewise displace the included old trap bed; at two of these fractures there are small masses of recent intruded trap making their way through the more ancient trap bed as well as the sandstone; and on the east side of the cutting, some distance removed from it, one of these intrusions assumes the appearance of a dyke five feet in thickness.

The sandstone, with its associated bed of trap, is now undisturbed for the distance of one hundred and twenty-five feet, when they are both abruptly cut through by a large funnel-shaped cleft or hollow, forty feet wide at top, and filled with brown clay and rolled masses of grits and primary rocks. Along the south face of this cleft a large mass or dyke of recent trap has burst up, and, attacking the lower surface of the old trap, appears to have melted it. The recent mass, having cut through the older bed, assumes the form of a wedge, about ten feet thick at the base, and cuts diagonally upwards through the bedding of the sandstone, having, close to its junction with the upper surface of the old trap, sent off a horizontal sheet of trap, one foot thick, into and parallel with the bedding of the sandstone. Below this flake of trap, one bed of sandstone remains, one foot thick, and which rests immediately on the upper surface of the old trap bed.

At the north side of the cleft, the old trap again appears, having resting on it eight feet of sandstone, which is capped by a bed of trap, six feet thick, which, from its mineral structure, I am induced to regard as recent. At the distance of thirty-four feet from the north side of this cleft we observe a fault displacing the beds to the amount of four feet, and then we have a large trap dyke, six feet thick, cutting vertically through the old trap and sandstone—the former appearing at the bottom of the section, and extending northwards for the distance of about twenty feet, when it disappears. The cutting dyke to which I have just alluded, is compact, light grey, coarse-grained, and vesicular in the centre,

but quite spheroidal and ochreous at the walls. Its strike is N. and S., crossing the railway cutting obliquely. At an elevation of about twelve feet from the bottom of the section it traverses a horizontal bed of recent trap, of six feet in thickness, which appears to have forced its way into the bedding of the sandstone. To the south of this dyke, and on top of the section—that is, about twenty feet above the level of the rails—there is a portion of a second bed of recent trap also resting uniformly on the sandstone. It is not improbable that both the trap beds last noticed may have been given off by this cutting dyke.

At the distance of nearly two hundred feet north of this dyke a mass of trap has burst through the sandstone, which is here thick bedded, coarse-grained, and compact, and it sends off to the southward two beds—the lower averaging two feet in thickness, and one hundred and thirty feet in length, the upper something more than one foot thick and forty feet in length, both beds following the bedding of the rock, into which they have been intruded; while to the northward the same rent has given off a thin flake of trap, averaging but one foot in thickness, and running along the bedding of the sandstone for the distance of three hundred and twenty feet, accurately following the various contortions and curvatures of the beds. In one place on the east side of the rails this bed is observed to branch into two, and in one instance on the west side of the section a thin trap bed tapers to a fine point, presenting the appearance of a succession of spheroids lessening in size.

Tedious and, perhaps uninteresting as a description such as this may be, I feel sure that a visit to the place which I have described will never disappoint any geologist; and if he possess a proper share of enthusiasm he will linger with pleasure over the striking tableau of former volcanic action there presented to him; and to detail the wondrous story there told with such mysterious simplicity and eloquent silence will ever recall to him, as it does to me, the first impressions of the place, which must be those of wonder and delight.

I will conclude my description of the remaining portion of the railway cuttings under consideration, by observing, that beyond the red sandstone at Faughart, the section exposes a mass of green grits and slates contorted and fractured in a singular variety of ways, and in the short distance of four hundred feet cut through

by four dykes of trap, the largest of which is six feet thick. They are all simple dykes, and do not seem to be connected as at the Faughart cutting.

At the distance of one thousand two hundred feet northwards a large elvan of porphyritic granite occurs at the east side of the railway, and even through this a trap dyke has found its way. I regret not being able to offer a detailed description of this portion of the line, as it was quite concealed by debris. Certainly the locality under consideration is, *par excellence*, the region of trap dykes.

Beyond this, as we approach Claret Rock Hill, the cuttings had not been commenced during the month of May last; and as they were intended to be to the great depth of fifty-four feet through the slates, I have no doubt but that many curious trap dykes will be there discovered.

At Claret Rock Hill the excavations are through the granite, and here trap again appears, cutting through the former rock in lines agreeing to its jointing. In the distance of five hundred feet the trap spreads out through the granite in flakes, seams, and threads—in some instances moulding itself to the joints, at others cutting directly through the rock, independent of all fissures. Those cuttings terminate at the small stream which forms the boundary of the counties of Louth and Armagh; and the last object visible in them is a trap dyke, striking north and south, and five feet thick.

Near to Jonesborough road the cuttings are through granite, and close to the stream south of the same locality a mass of trap, from forty to fifty feet in thickness, appears in the granite, apparently affecting it so much at its junction as to cause the latter rock to decompose into a green friable mass for the distance of many yards north and south of the trap.

This paper was illustrated by the detailed sections prepared for the Geological Survey of Ireland, to a scale of forty feet to the inch.

"On the cuttings of the Belfast and Ballymena Railway," by **James M'Adam**, Esq., F.G.S., Lon.

The Belfast and Ballymena Railway being now finished, it may not be uninteresting to describe some of the phenomena presented to the geologist in the cuttings. None of the cuttings being very deep, there is not the variety of geological structure brought to view that might have been expected in a section wholly in the county of Antrim. However, some of the phenomena are very striking, and a description of them should be preserved by way of record.

On leaving Belfast the course of the railway is along the north side of Belfast Lough, and is upon an embankment until it reaches Macedon Point, where there is a cutting through variegated marle, containing gypsum, and a whyn dyke is also traversed; the dyke, like the rest in the county of Antrim, runs almost north and south, but it has a peculiarity in its being inclined, or with a sloping side, and not perpendicular. The marle contains various thin subordinate beds of sand; but it is worth mentioning, as a botanical fact, that the year after the cutting was made in the marle, the sides became covered with the common weed, the Sinapis arvensis, a cruciferous plant containing sulphur, which it evidently elaborated from a soil rich in sulphate of lime. At Macedon the railway leaves the shore, and proceeds through shallow cuttings of surface soil to Carrickfergus; a short way from which place it branches off towards Ballymena, and going inland we come to the first cuttings through rocks, at Mossley. Here the section through the trap rock is very instructive, as a portion of the earth's surface is ripped open in a way that enables us to observe the phenomena very closely. The surface soil is from six to ten feet in thickness, and contains loose pieces of trap of a large size; underneath is the trap rock in situ, which, near the summit of the cutting, has a bedded appearance, and contains many white veins formed by infiltration. It is very hard, especially in the upper beds, and is also amygdaloidal in its mass, containing vast quantities of imbedded minerals, as steatite, calcareous spar, and several kinds of zeolites; some portions of the trap are loose grained, and in this state they exhibit very instructively the minerals augite and feldspar, of which the mass of the trap is composed. Descending in the cutting, rubbly beds are interlaced with the hard beds, the whole being generally

horizontal; the lower portions are very red coloured, and towards the eastward it has sometimes an arenaceous aspect. The concretions are of all shapes; but the structure, especially of the hard, is generally tribedral, as may be frequently observed in other localities. Towards the westward the beds become more inclined in that direction, and are sometimes of a greenish colour. We often see masses of a concentric structure, having hard nuclei, with softer matter about them; these concentrics are often visible in the middle of the beds exposed at the sides of the cutting, and exhibit a very beautiful appearance.

On leaving Mossley the railway cuttings are, for a considerable way, through superficial soil and bog. We observe frequently rolled pieces of chalk and flint in the soil, the occurrence of which can only be explained by there having been at one period a denudation in the neighbourhood, and large portions of the chalk formation swept away, leaving debris behind it. This denudation will account for some of the open spaces in the hills about Belfast, and the occurrence of chalk and flint gravel not only in that neighbourhood, but in the opposite county of Down, where it is very abundant.

The next interesting cutting through trap is in Ballypallady, at Steenson's quarry. The trap here presents a beautiful appearance, being hard, amygdaloidal, and very rich in zeolites, especially chabasie of a very fine description. As at Mossley, the upper part of the trap has a bedded aspect; but the whole mass is formed of concretions, generally having greenish steatite in the interstices. These concretions seem to be largest near the surface. In this quarry is a curious vein of ochreous-coloured trap, almost perpendicular. The embedded zeolites are extremely fine, and the mineral collector would here obtain a rich harvest.

On leaving Ballypallady, the railway passes along an embankment, on which are many pieces of an ochreous substance; the remarkable appearance of which at once strikes the geologist, who becomes curious as to where the like occur in situ. His curiosity is gratified at the next cutting in Ballyhartfield, which is the most remarkable on the whole line of railway, and is perhaps one of the most interesting sections afforded by any line of railway in this country.

At the eastern end of the cutting at Ballyhartfield the trap comes down to the bottom, rising as we go westward, and covering by a

thickness of only a few feet the subjacent beds. It frequently contains concentric concretions, similar to those in the other cutting, but much finer, sometimes giving it a rude columnar aspect. It contains many druses, in which are steatite, carbonate of lime, mesotype, and chabasie—the steatite sometimes occupying the middle of the druse, surrounded with one of the other minerals. Under this is a seam of dark buff ochre or lithomarge, succeeded by a black seam affording, according to the analysis of Dr. Hodges, Professor of Chemistry in the Belfast Institution, about nine per cent. of carbonaceous matter. Under this are several beds of ochres of various colours, red, lilac, buff, brown, &c.; some beautifully speckled; the whole presenting, before the sides were soiled over, an appearance resembling a painted geological model; in fact it is almost impossible to convey in words an idea of the geological beauty, (so to say,) of this section. Throughout these ochres there are many concentric concretions similar to those in the trap, and which are very remarkable objects; the nuclei being sometimes trap with layers of ochre about it, and sometimes the entire concentric is composed of ochre; one was very remarkable, its centre being of a light blue colour, with thin yellow surrounding layers. The following is the result of the analysis of this ochre by Dr. Hodges:—

Silica, ...	26.0
Alumina, ...	26.93
Per oxyd iron, ...	35.57
Magnesia, with a trace of lime, ..	0.73
Water, ...	10.33
Loss, ...	0.44
	100.00

This ochre is of frequent occurrence in other places in the county of Antrim, and from the quantity of iron which it contains, it has become an object of interest in an industrial point of view. At Newton Crommelin experiments were made on a large scale, for the purpose of smelting it with peat charcoal, and it yielded excellent iron, but for so far no work has been established for the purpose of commerce. It might also be easily manufactured into a pigment.

The section at Ballyhartfield displayed some interesting whin dykes, in the vicinity of which the concentric concretions above

mentioned generally become more numerous; between the dykes and the adjoining beds there is sometimes a seam of earthy matter. In the overlying trap, as well as in the dykes, there are thin veins of a white substance, evidently formed by infiltration, the analysis of it showing it to contain eighty-three per cent. of carbonate of lime. Before leaving Ballyhartfield it may be right to observe, that it is the only cutting on the line of railway in which the trap is wholly cut through, so as to give a good idea of the beds underneath.

Proceeding westward into the townland of Ballymartin, the railway passes through a cutting somewhat similar to that in Ballyhartfield. Here the trap has a bedded appearance, and is somewhat decomposed; a blackish clay underlies it, sometimes eighteen inches thick. There is also a dyke, and several concentric concretions, one of which was three feet in diameter. Proceeding farther in the course of the railway, the next cutting is through the upper part of the trap, after which there is no deep cutting through rocks for the rest of the line.

The next remarkable appearance is at Templepatrick, where, under the embankment, at a bridge across the old Belfast road, is a bed of light-coloured compact feldspar. This bed seems to have escaped observation, as it is not recorded by any geologist. It is of no great extent, and is evidently a subordinate bed in the trap, which is found in the railway cutting at both terminations of the feldspar. It was analysed by Mr. W. B. Ritchie, of Belfast, who found its composition to be—

Silica, ...	69.250
Alumina, ...	16.350
Potash	3.150
Soda, ...	4.400
Magnesia, ...	2.450
Protoxyd Manganese, ...	0.300
Lime, ...	0.700
Water, ...	3.400
	100.000

This bed of feldspar is highly deserving of observation, as it may in some degree account for the occurrence of trachyte, composed chiefly of feldspar, which is found in different parts of the Antrim trap district. A considerable extent of it, of a porphyritic character,

occurs in the hills called the Sandybraes, about five miles from Templetatrick, and from the occurrence of boulders both of compact feldspar and trachyte in the cuttings of the railway for several miles west of Templepatrick, there must have been former beds in other places, which have been denuded, and in all probability there are others concealed by the surface soil.

As trap may be regarded as a mixture of feldspar with augite or hornblende, the occurrence of subordinate beds of feldspar may be explained by the circumstance of the other mineral being absent under the conditions in which the igneous rock was formed.

Proceeding onwards towards Antrim, at the cutting near Mr. Chaine's cottage, the work was carried fifty feet through beds of gravel dipping about north-west, under which was a bed of loose boulder stones, in which there was found, about forty feet in from the face of the cutting, a mass of a kind of dry straw, a very puzzling phenomenon, as it is difficult to account for its occurrence in such a position under such a mass of superincumbent gravel. The boulders in which it was found were of the usual local character, trap and the above-mentioned compact feldspar.

Going nearer towards the town of Antrim there are tolerably deep cuttings through gravel hills, the gravel consisting of trap, ochre, feldspar, chalk and flint, all evidently derived from the neighbourhood. There is also much sand intermingled with clay that seems to have resulted from decomposed trap, and there are frequently alternating layers of sand and fine gravel; sometimes rolled chalk fossils are found in the cuttings. There must have been a denudation of chalk towards Lough Neagh, as pieces of it are found in the soil all about Antrim, and as far as Magherabeg, four miles onwards to Ballymena, beyond which Mr. Robert Young, the assistant engineer who superintended the cuttings, informed me he did not observe any.

Between Antrim and Ballymena the railway cutting is through drift and clay, with a single exception at Drumsough, where the cutting is for a short way through trap rock. Throughout the whole extent of this part of the line, there is found to be a blue clay underlying the local drift. This clay being so extensive, and occurring invariably under the drift, renders it probable that it is an ancient lacustrine deposit, showing a different condition of the surface formerly, but as yet too few facts have been brought to light

to come to any certain conclusion. Underneath it is the trap rock, as was proved by a cutting entirely through it at Tullygarry when the trap was reached. Between this clay and the drift there are frequently seams of sand, in which are often found pieces of fossil wood resembling those of Lough Neagh in various degrees of fossilization, from almost recent to hard stone. This occurrence of petrified wood is an additional argument in favour of the blue clay being a lacustrine deposit. In this clay at the Irish hill near Ballymena, there was found a rolled fossil resembling the Unio Listeri of the lias formation, which is a very puzzling fact, considering that no lias is now known nearer than the sea coast.

In the drift between Antrim and Randalstown, there are boulders of mica slate, granite, ironstone and sandstone, all of which must have come from Derry or Tyrone. Mr. Bryce, in a communication to this Society soon after its commencement, mentioned some facts corroborative of the supposition of a drift of boulders from the north-west over this part of Ireland, and the fact of the occurrence of those just mentioned near Randalstown would be an additional argument in its favour. Nearer Ballymena the boulders seemed to be all trap. Mr. Young, who observed closely during the time the cuttings were made, could perceive no other.

The only other fact worth relating is, that between Antrim and Ballymena the drift often encloses portions of bog, as if there had been a bog at one time put in motion and broken in pieces, which were arrested in a lake of mud. It is singular, that some years ago a bog near Randalstown was moved from its place, which still bears the name of "Moving Bog." Similar catastrophes have consequently occurred both in ancient and modern times.

AT THE

ANNUAL GENERAL MEETING,

HELD ON

WEDNESDAY, FEBRUARY 14th, 1849,

THOMAS OLDHAM, ESQ. PRESIDENT, IN THE CHAIR.

The following Report from the Council was read :—

IN compliance with annual custom, your Council have to offer to you their report on the progress of the Society during the past year.

At the commencement of last session you are aware that this Society had moved into the University, the Rev. Dr. Lloyd and the Rev. Mr. Graves having both offered to your Council any accommodation which their rooms could afford. Your Council, after consideration, determined to accept Dr. Lloyd's offer, and took advantage of the excellent room in No. 35, College, which is now occupied by your books, maps, &c., and in which your Council has regularly held its meetings. The liberal offer of Professor Graves was consequently declined, with the warm thanks of the Council. Subsequently finding that the lecture room in the engineering school—the use of which had been liberally accorded to the Society for its evening meetings, by the Board of the University—was not well adapted for such meetings, it was resolved, that the evening meetings also should be held in the Council room, which, though not very well suited for meetings, has been found sufficiently comfortable hitherto.

Towards the close of the session the College was occupied by military, and the public mind much unsettled, so that it appeared to your Council that the succeeding meetings for the session could neither be held with convenience or utility; they therefore deemed it advisable to adjourn the two meetings which should have taken place in May and June. The present session was opened at the

usual period in November, by an address from your President on the progress and prospects of the Society, to which address your Council refers you with much gratification.

During the past year three new members have been added to your Society.

Your Treasurer's accounts, which are annexed, exhibit a balance in favour of the Society of £62. 8s. 5½d.

Abstract of Accounts of Geological Society, for the year ending February, 1849.

Dr.	£.	s.	d.
To Balance in Treasurer's hands on last year's Account,	39	6	9¼
— One Life Subscription,	10	0	0
— Annual Subscriptions, including arrears,	70	0	0
— Produce of Articles of Furniture sold,	0	8	0
	£119	14	9¼

Cr.	£.	s.	d.
By sundry small expences, per the Secretary's Book,	4	17	4
By Mr. S. B. Oldham's account for Printing, &c. for last year,	26	0	6
By Porter's Wages, eight months to Oct., 1847,	8	0	0
By Mr. S. B. Oldham's account for Printing, &c. for this year,	7	17	3
By Sundry small expenses per book, including Porter's Wages,	7	3	3
By Collector's Poundage on Subscriptions,	3	8	0
By Balance in favour of the Society,	62	8	5¼
	£119	14	9¼

We have examined the above account, and find it correct, with balance in Treasurer's hands, £62. 8s. 5¼d.

ROBERT CALLWELL.
W. H. HARVEY,

21st February, 1849.

DONATIONS

RECEIVED SINCE THE LAST ANNIVERSARY.

1848.

Mar. 8.—Two fine Septaria, handed over to Museum, T.C.D., presented by R. Mallet, Esq.

May 3.—Specimens of Shale, with ripple marks, from Milltown Malbay, presented by Rev. Professor Graves.

London Philosophical Society Report for 1846—7, presented by the Society.

Quarterly Journal of Geological Society, 1st May and 1st August, 1848, presented by the Society.

Memoirs of Geological Survey, 2 parts, vol. 2, presented by the First Commissioner of Woods and Forests, per Sir H. De La Beche.

Reports of the Literary and Philosophical Society, Liverpool, presented by the Society.

Reports of Geological and Polytechnic Society of Yorkshire, 1845—6, by Society.

The Geological Map of the Co. of Wicklow—Plan of the Ovoca mines—four sheets of horizontal sections, published by the Geological Survey of Ireland, presented by the Chief Commissioners of Woods and Forests, through Sir Henry De La Beche.

The Mining Journal, by the Editor.

Report of the British Association for the Advancement of Science, for 1847, presented by the Association.

Report of the Proceedings of the Geological and Polytechnic Society of West-Riding of Yorkshire, (Leeds,) presented by the Society, 14th November.

Quarterly Journal of Geological Society, for November, 1848, presented by the Society.

Transactions of the Royal Scottish Society of Arts, vol. 3, parts 2 and 3, by the Society.

Wissenschaftliche Beobachtungen auf einer reise in das Petschora-land, from Count Keyserling, per Sir R. I. Muchison.
The Mining Journal for the past year, by the Editor.
Quarterly Journal of Geological Society, February, presented by the Society.

Resolved.—That the Reports now read be confirmed, and such parts of them, together with the Treasurer's accounts, as the Council may think fit, be printed, and circulated among the Members.

A ballot then took place, when the following gentlemen were elected Officers of the Society for the ensuing year:—

President.

PROFESSOR OLDHAM.

Vice-Presidents.

SIR H. T. DE LA BECHE, C.B.
JAMES APJOHN, ESQ. M.D.
REV. H. LLOYD, D.D. S.F.T.C.D.
RT. HON. THE LORD CHANCELLOR.
LT. COL. PORTLOCK, R.E.

Treasurer.

WM. EDINGTON, ESQ.
S. DOWNING, ESQ.

Secretaries.

ROBERT BALL, ESQ.
ROBERT MALLET, ESQ.

Council.

C. W. HAMILTON, ESQ.
JOHN MACDONNELL, ESQ.
THOMAS HUTTON, ESQ.
GEORGE WILKINSON, ESQ.
ROBERT CALLWELL, ESQ.
PROFESSOR ALLMAN,
MATTHEW D'ARCY, ESQ.
CAPTAIN LARCOM, R.E.
F. W. BURTON, ESQ.
REV. C. GRAVES, F.T.C.D.
REV. S. HAUGHTON, F.T.C.D.
RICHARD GRIFFITH, ESQ.
PROFESSOR HARVEY,
JOHN KELLY ESQ.
PROFESSOR HARRISSON, M.D.

The President then read the ANNUAL ADDRESS. After the address had been concluded, the following Resolutions were unanimously passed:—

"That the cordial thanks of the Society be presented to the President, for his constant exertion in the cause of the Society during the past year."

"That the warmest thanks of the Society be presented to the several Officers of the Society, for their zealous attention and endeavours to promote the objects of the Society during the past year."

The Society then adjourned.

ADDRESS.

The established custom of your Society, Gentlemen, devolves upon your President the duty of annually laying before you a brief statement of your progress, and of the advance of the science, for the cultivation of which you are associated.

It is to me a source of sincere gratification, that I am able to announce to you, that our Society has progressed during the past year. The memorable events of that period are no doubt fresh in the recollection of all; and although science acknowledges no politics, it is not, amid the bustle and anxiety of unceasing change—amid the upsetting of all established order—amid the crash of kingdoms and the ruin of the ordinary ties of society, that we can fairly look for the progress of knowledge, and the increase of learning. The mind cannot readily revert from the harassing anxieties of thoughts and cares which are impressed upon it by the general aspect of affairs around, to the useful and continuous investigations of science. And dead, indeed, to all the emotions of pity and of charity, must that heart have been, which could have watched, unmoved, the painful scenes of the past year. We *are* not, therefore, we could not be, surprised to find that the wonted energy of our members was in a slight degree diminished; and that several, who before were our most constant and steady supporters, have been compelled to absent themselves from our meetings, by the almost incessant demands upon their time and exertion, which the state of those around them involved.

You are also aware, that during the period of excitement and dreaded disturbance of last year, many of our public buildings were wisely occupied by her Majesty's troops, and the University among the number. It was, therefore, considered desirable to suspend the

meetings of this Society for two evenings. On all the other evenings of meeting, however, I am glad to inform you, that we were fully occupied with matter of interest and importance, that new members, (scarcely to be expected under the circumstances,) have been added to our body, and that the Treasurer's accounts show a considerable balance in favour of the Society.

This appears to me, gentlemen, a very strong acknowledgment of the value of our Association, and of the interest which many are beginning to take in our pursuits. We are satisfied that that interest once excited, cannot diminish. As our knowledge increases, the enjoyments connected with it increase too; and to none, save those who have been in some degree admitted to the shrine of nature, is the intensity of that calm, and deep, and soul-enjoyed delight known, with which they turn from the ever-varied torments of petty dissensions, and increasing contests which surround them here, to the contemplation of the works of Him "with whom is no variableness, neither shadow of turning." Into what utter insignificance do the revolutions of earth's kingdoms sink, when contrasted with those mightier revolutions which geology opens up to our view. How rapidly does the pride of man sink before the conviction which such discoveries impress upon him. Such pursuits are not, then, without their moral influence; and the heavenly harmony which they produce, amid the jar and discord of things around, is not the least delightful resource which they afford.

There are, gentlemen, two courses open to your President, on such occasions as the present; either to confine himself to a simple analysis and review of the matter which has been brought before the Society during the year; or to take a general review of the progress which has been made here and elsewhere in our science, and its allied pursuits. The latter, although unquestionably the more difficult task, and one for which many of the necessary means are wanting in this city, would yet appear so much the more useful, that, however imperfectly, I shall prefer giving you in some degree a summary of what has been thus done, to a dry detail of the points laid before ourselves alone, with most of which, I must presume that you are already acquainted.

The intimate connexion which exists between all branches of our enquiries—a connexion which is every day becoming more close and defined—renders it exceedingly difficult to adopt any classification of

subjects, which will not be in many respects objectionable. No memoir on descriptive geology would be considered complete without an accompanying investigation of the organic remains, (if any) contained in the rocks described; or a careful examination of the peculiar mineral arrangements exhibited. We may, however, divide our enquiries, with some advantage, into those belonging more properly to descriptive geology, mineralogy and its applications, including what may be denoted chemical geology, and palæontology; while there would yet remain a very important branch of our studies, including all the practical and useful applications of the scientific principles established. I shall endeavour in some degree to follow this classification.

Descriptive Geology.

The continuation of M. Andrè Dumont's description of the rocks of the Ardennes, and the Rhine, Brabant, &c., has been published during the past year;* the first portion having appeared in 1847. This detailed paper is characterized by an account of minute lithological and mineralogical description, rarely met with in geological papers of the present time; and taken in connexion with the author's former valuable description of the province of Liege, has added much to our knowledge of the mineral structure of those interesting districts, and has tended to elucidate several points over which some doubts hung. Having in the former portion of his treatise described the "*terrain ardennais,*" or what he considers the silurian rocks of that country, and which he divided into three systems or groups—

The systeme Devillien,
,, Revinien,
,, Salmien,

so named from the localities where they were found best developed, M. Dumont now enters on the consideration of the "*terrain rhenan,*" which he considers the equivalent of the Devonian system of English authors. This formation he also subdivides into three groups or systems—

1.	Systeme	Gedinnien,	1st lower,
	,,	,,	2nd upper,
2.	,,	Coblentzien,	1st lower, or Taunusien,
	,,	,,	2nd. lower, or Hünsdruckien,
3.	,,	Ahrien.	

* Mem. de l' Acad: Roy: de Belgium. tom. xxii.

The prevailing mineral structures are sandstone, quartz, conglomerate, slates, with occasional bands of limestone.

In this classification, or rather in the referring these rocks to the English representatives, as M. Dumont has done, it may be recollected that he differs entirely from Sir R. Murchison and Professor Sedgwick, who in their memoir "on the distribution and classification of the older or palæozoic rocks of the north of Germany," (read in 1840,) came to the definite conclusion, that these rocks all belonged to the silurian and cambrian group, and summed up this portion of their paper in the following words:—

"1. That considered on a broad scale, the succession of a natural group of strata, and the successive natural groups of fossils, are in approximate accordance.

"2. That as the broad areas of the physical groups of strata are ill defined, so also are the boundaries of the fossil groups ill defined, and pass into one another.

"3. That as there are no great mineralogical interruption of the deposits, producing a discontinuity or want of conformity among the masses, so also there seems to be no want of continuity among the groups of the great palæozoic series of animal forms."*

The lists of fossils, confessedly incomplete, which Professor Dumont gives, are not sufficient to decide this question, although the group as given has as much a devonian aspect as silurian; but he grounds his classification on an important physical fact: namely, that there is, he states, a very distinct and marked unconformability between the rocks of the *systeme ardennais,* (said to be Cambrian, by Murchison, and Sedgwick,) and the *systeme rhenan;* while all the subdivisions of each of these formations, as compared among themselves, are perfectly conformable.

This is an important fact, not seen by Murchison and Sedgwick; and though by no means sufficient grounds in itself, for referring either of the groups to the parallel that M. Dumont assumes, points to a remarkable change in conditions during the period of the formation of this great series of rocks. However this question may be finally settled by a more full and complete investigation of the fossils, M. Dumont has given a very detailed and carefully drawn up description of the mineral structure of the rocks. Nor are such enquiries,

* Trans. Geol. Soc. London, Vol. VI. Page 283.

by any means, confined in their interest to the locality to which they refer, but bear most importantly on English geology; and on that great question which must soon be more definitely settled, and for the determination of which, Ireland will in all probability afford the best key—of how far the devonian system can be recognized *as a system*. Its domain has been invaded from below by the silurian group, and the character of the important fossils from the carboniferous slates and yellow sandstone of Mr. Griffith, seem to point to an equal invasion from above. The south and south-west of Ireland will, in all probability, prove the means of establishing the true divisions of these groups.

The Rev. W. Clarke* commenting on the description of Australian fossils, by Mr. M'Coy, published in 1847, and the conclusions arrived at, (that the coal beds of that country were of the age of our oolitic period, and had been formed after a long interval had elapsed subsequently to the production of the palæozoic rocks of the same district,) endeavours to prove that this cannot be the case; for the, beds of coal are regularly interpolated in the series from which the older fossils have been derived, and has furnished further illustrations of the subject.

A somewhat analogous case is the disputed occurrence of belemnites in the same series as true coal-measure plants in the Alps of Savoy.

In November, Mr. Bunbury brought this case before the Geological Society of London. So long since as 1828, M. Elie De Beaumont had stated, that in the Tarentaise beds of black schist, which contained remains of ferns and other plants identical with those found in the English and French coal formations, were interstratified with beds of limestone, containing true belemnites. He referred the whole group to the age of the lias. M. Brongniart distinguished seventeen forms of the plants, only two of which were peculiar. Mr. Bunbury has also identified several with plants found in our, and in the American, coal fields. Sir R. Murchison has equally acknowledged, that the coal plants appear to lie in the same beds with the belemnites; and though not offering a definite opinion, seems to think that E. De Beaumont's identification of these beds, at Petit cœur, with the lias, is correct.

* Annals Nat. His. Sep. 1848.

Mr. Sharpe, on the same evening, described the occurrence of beds of anthracite, near Oporto, containing vegetable impressions, strongly resembling those of the coal measures under slates, in which numerous fossils were found, many of which were identical with lower-silurian fossils of northern Europe. And that thus the coal-producing beds of Oporto are in the same series of rocks, as with us are referred to the silurian formations. It need not be insisted on here, that the term "coal formation," if intended to imply a definite position in the series of stratified rocks, is worse than useless. That the conditions favourable for the abundant growth of vegetable productions, and for the subsequent entombing of those plants, under circumstances tending to effect that peculiar change in their composition, which has resulted in the formation of coal, that these conditions have been frequently repeated in certain places, and after long intervals of time, is well known to geologists, and might, *a priori*, have been anticipated. We know that the slight traces of such conditions, which the occurrence of small portions or thin layers of jet exhibit in Yorkshire, become more marked in the thicker beds of coals intercalated with oolitic beds in Sutherlandshire. There is, therefore, nothing to surprise us in the fact of beds of coal being found associated in other countries with older rocks, than those with which they occur here; but the extension of the flora, which in these countries characterizes the newer secondary rocks, into the older groups of rocks which occur in Australia, adds another remarkable instance to the peculiarities which the geological character of that district presents; and offers a most striking and most valuable hint to geologists, on the importance of studying the succession of rocks in each country, by an examination of that country alone, before they venture to force them into a parallelism with the series which may have been described in other districts.

The great proposition of Smith—that formations, and even beds, can be recognized as being of cotemporary formation at great distances, by the identity of the fossil remains contained in them, is only true when limited to areas, which appear to have been geographically united, or the same; and even then is not *strictly* correct either; but on the other hand, the occurrence of the same organic remains in beds separated geographically by such intervals, as that between us and Australia, or even Oporto, instead of proving, or even going to prove, the synchronism of the formation of the

beds in both places, proves *precisely the opposite;* and any attempt to establish the identity of the period of the formation of the rocks from an identity of the organisms peculiar to them, must fail, and fail, simply because founded on erroneous reasoning. Take, for instance, the existing faunæ of these two countries. Were fossiliferous beds being formed now in the Australian islands, subjected to examination by an English geologist, who was unacquainted with the existing fauna of that district, he would find in them, among a large number of organic remains peculiar to them, others extremely similar to those which in this country belong to the oolitic group, (trigoniæ, marsupial animals, &c. &c.) and from this might conclude that these beds were of the same age as our oolitic beds; but how erroneously I need not point out.

Again, in the very oldest rocks which we have, many species are known, common to this country, to northern Europe, and to America; now some of these appear much earlier in the silurian series in Germany than with us; others, again, are found in lower beds with us than on the Continent; and the same laws hold with regard to America. These species are, therefore, considered as separately, Germanic, British, or American species, that is, to have had their first origin or appearance in these countries, and their appearance in other countries, can only have been *after the lapse of a sufficient time* to permit of their distribution.

From similar reasons, the occurrence of such cases of fossils, which in these countries belong to distinct systems associated in the same beds, rather suggest important facts and laws as regards the mode or rapidity of distribution of the various species or genera of animals and plants, than any real contradiction to the established facts of geology. It is only when the analogy of existing nature is forgotten, or overlooked, that we are liable to be led astray by such facts. This, and this alone, is the source of all our knowledge with respect to the existence of former periods; and this, and this alone, can, therefore, be the true guide in such investigations.

Bearing on rocks of similar age to those which M. Dumont has described in the memoir to which I have referred, the valuable summaries given by Professor Ramsay and Mr. Aveline, on the structure of parts of north and south Wales,* and by Mr. Jukes and

* Quar. Jour. Geol. Soc. London, April, 1848. No. 16, page 294.

Mr. Selwyn, on the country extending from Cader Idris to Moelsiabod,* possess an interest for the Irish geologist, quite independently of their importance, as containing the result of the detailed and accurate examination of the district in connexion with the Geological Survey of Great Britain. During the year, I had myself also the honour of laying before this Society the results of the examination of the County of Wicklow; and these papers of my colleagues, are peculiarly valuable as illustrating by the examination of a country in which the series can be much more carefully made out, owing to the much smaller amount of detrital covering, the same succession of rocks, on the large scale, which are recognizable here. In Mr. Ramsay's paper, a case of unconformability in the silurian series, (the caradoc system resting transgressively on the lower beds,) is pointed out, which may recall the similar fact noticed by Dumont. And in this and the other communication we have a succession pointed out, which can be almost perfectly paralleled at this side of the channel. Thus the Barmouth and Harlech sandstones are the undoubted representatives of the similar rocks, which occur in our neighbourhood, at Howth, Bray-head, Devil's Glen, &c. &c. "The trappean group," is equally represented in Wicklow, as our map will show; and the valuable communications of Professor Forbes to this Society, during the past and preceding year, have shown clearly, that we have in more places than one, the representatives of the "Bala" beds also. I would also refer, with pleasure, to the important memoir of my colleague, Mr. Phillips, as bearing closely on the investigation of similar districts in Ireland; I can, however, only allude to these papers for reasons which will be obvious.

In May last, Mr. Moore brought before the Geological Society of London some fossils, derived from the old slate and grit beds of Wigtonshire and Ayrshire, which, on a comparison by Mr. Salter, were found to agree in part with fossils from the similar rocks in Wicklow and Wexford. It is remarkable also, that the slaty system of this portion of Scotland has the same general strike to east north-east, that the rocks of Wicklow and Wexford have; but they appear to differ, according to Mr. Moore's account, in not having any true slaty cleavage, which abounds in the south-east of Ireland. What may have been the cause of the prevalence of this structure in one

* Quar. Jour. Geol. Soc. London, April, 1848, No. 16, Page 300.

portion of a district, and its absence in another, while both seem composed of precisely similar rocks, and to have been subjected to similar disturbances, is a question opening up many points of interesting research.

Although not read within the last year, yet, as it has only been published then, we would refer to the papers,* by Mr. Binney, of Manchester, whose zeal and energy in the examination of his neighbourhood are well known to British geologists. In a paper, "On the origin of coal," Mr. Binney has embodied the results of a careful investigation of the relations of the coal field about Manchester. The coal measures are stated to be at least six thousand six hundred feet in thickness; that there are in this, one hundred and twenty different seams of coal; and that in the floor of all which Mr. Binney has seen, (eighty-four in number,) remains of *stigmaria ficoides* have been found. This important and general fact was first made known by Mr. Logan, with reference to the South Wales coal field.† Mr. Binney also endeavours to trace the currents which may have acted during the formation of the coal, as connected with a gradual subsidence of land, and concludes that, in most cases, the vegetables from the mineralization of which coal has been formed, were aquatic. Such papers of local detail and minute information, only to be acquired by a long and continued residence, are of great value.

Mr. Binney has also contributed a "Sketch of the geology of Low Furness, Lancashire," in which he describes the several rocks which occur in the district, "between the mouths of the Leven and Duddon, bounded on the north by a line from Ireleth to Ulverstone, and on the south by Morecambe Bay," and notices the interesting mines of Hœmatite, so long and so profitably worked in that district. He concludes by pointing out the great probability of there being a coal field underlying the southern and western portions of Low Furness.‡ It is in this way, by pointing out the probabilities of a successful application of enterprise, rather than by actually exhibiting the results of such, that our science can essentially aid the progress of our social condition, and increase the resources of our country.

* Lit. and Phil. Soc. of Manchester, Vol. VIII. New Series, Page 148.

† Geol. Trans. Lon. Vol. VI. Page 491.

‡ Mem. Lit. and Phil. Soc. Manchester, Vol. VIII. Page 423., &c.

Before passing to the consideration of the additions made to our knowledge of the more recent sedimentary rocks, we must delay for a moment to allude to an important communication made during the past year, first to the British Association at Swansea, and subsequently in an enlarged form, to the Geological Society of London, by Professor H. D. Rogers. We cannot speak in terms of too high praise of the ability displayed by Professor Rogers, in the beautiful illustrations with which his communication was accompanied, and the eloquent and masterly manner in which his views were enunciated. The state survey of Pensylvania, which has been executed by Professor Rogers and his colleagues, formed the groundwork of this paper; but the views announced were by no means limited to this district. Touching the descriptive portion of the paper, Professor Rogers pointed out the general accordance in succession, which the rocks of North America present, as compared with those of Europe; he stated the many reasons which had led them to conclude, that at the period of the formation of the palæozoic group of that country, there had existed an ancient continent, where now is the Atlantic; the strata further west than the Apallachian chain being the deep sea representatives of the more shallow water deposits found in that range. That after the elevation of a great portion of this region, the sea still covered the whole of Florida, the plains of Arkansas, extended up the Missouri, and along the Atlantic plain to New Jersey. Over this area was deposited first the cretaceous, and then the tertiary series. Professor Rogers pointed out the remarkable circumstance, that along the western boundary of the unfossiliferous rocks, which occur between the tertiary plain and the Apallachian chain, and for a length of one hundred and ten to one hundred and fifty miles, the "*newer rocks all dip under the older.*" This remarkable fact had first been explained by Professor Rogers, who showed that it was due to the folding over of the rocks. To describe this a little more in detail; the Appalachian zone has a mean breadth of one hundred and fifty miles, and is stated to consist of five distinct and parallel belts. Crossing them from south-east to north-west, it is found that the form of the flexures or contortions of the rocks gradually alters; in the first two belts, the palæozoic rocks are doubled into sharp, closely compressed alternate folds, which dip, as a whole, at high angles to the south-east, or *towards* the chief source of disturbance: dykes, and mineral veins,

parallel to the strike of the beds abound here. In the third belt, or the great Appallachian valley, the oblique flexures or folds are somewhat less compressed, and the inverted or north-west sides of each anticlinal curve come nearer to a vertical position. In the fourth belt, or that of the great Appalachian chain, the flexures gradually expand, and the steepness on the north-west side of the anticlinal arches gradually diminishes. And in the fifth belt, that of the bituminous coal regions of the Alleghany and Cumberland mountains, the curves dilate and subside into broad symmetrical undulations with very gentle dips. The "axes planes" of these curvatures, therefore, or those planes which bisect the anticlinal and synclinal flexures, dip in the more plicated belts invariably to the south-east, and only approach the vertical when the curves become symmetrical, and the flexures flatten down: that is, the prevailing dip is *towards* the source of disturbance. These folds are also stated to lie in groups, each group having a certain distinctive character belonging to it.

The author next shows, that there are two systems of dislocations; one, small short fractures, perpendicular to the strike of the beds; and another, of enormous dislocations, extending for great lengths, parallel to the folds or axes of those flexures. These latter are said to occur almost invariably *at the synclinal folds*, or *at some point in the inverted leg of the anticlinal*, thus causing older strata to lean unconformably on newer ones. Some of these dislocations are said to cover eight thousand feet of strata.

The planes of cleavage are also stated to dip, on the whole, in the direction of the axes planes of the flexures; and with a dip approximately parallel to the dip of these planes. The same rules were stated to be applicable to the Alps, the Rhine, &c., and to all such disturbed districts. Sueh are the principal facts stated by Professor Rogers in his important communication.

To account for these, the author proposes to explain the great flexures of all disturbed districts, by supposing that "the thin and flexible crust of the earth has been at successive periods exposed to excessive tension, and has ruptured along lines." This rupture, or sudden relief of tension, would produce in the liquid mass beneath the crust, *two receding sets of huge waves of translation, which would throw the crust into corresponding undulations*; and at the same time press, or partially carry forward with them, the two pul-

sating zones in the directions of the advancing waves. During this wave-like motion, the crust below each trough, or concave bend, would crack and open downwards, and melted matter would rush in and fill the wedge-shaped fissures, and partially congealing would assist, in combination with other pressures, to prevent the mass from flattening out again; and thus the temporary flexures would be braced into permanent arches. Then "each succeeding set of similar billows of translation, starting from the same or parallel lines of rupture, would, by acting on the flexures already formed, contract their horizontal width, increase their curvature, and augment the difference in their anticlinal dips, even to the extent of a complete inversion of the forward side, with production of parallel oblique folding." I have quoted these words from the abstract of Professor Rogers' paper given in the Athenæum,* which, from my own recollection, and from notes taken at the time of his reading his paper to the British Association at Swansea, appears to me to represent his views accurately, because I wished to convey these views as clearly and fully as possible; and probably we will obtain even a clearer insight into his opinions, by taking, in connexion with these, the words of the same author, in originally announcing his views at the British Association meeting, at Cork, in 1843, when he said, that the wave-like motion of the earth's surface during an earthquake, is of the nature of an "actual billowy pulsation in the molten matter upon which they suppose the crust of the earth floats, engendered by a linear or focal disruption, and immediate collapse of the crust, accompanied by the explosive escape of highly elastic vapour," and they then speak of "progressive waves of oscillation," thus produced, &c. &c.†

Now the untenability of such an idea of motion, as applied to earthquakes, has been so fully, and so satisfactorily shown, by Mr. Mallet, in his able essay "On the dynamics of earthquakes,"‡ that it would be needless for me to enter upon the question, or point out the inapplicability of such reasoning to explain the phenomena of contortions as here seen. Professor Rogers has himself seen one of the difficulties, and has attempted to account for it. He has obviously seen, that if his notion of such billowy waves be correct,

* Athen. No. 1101, 1848, Page 1210. † Brit. Ass. Reports, 1843, Page 57.
‡ Trans. Roy. Irish Acad. Vol. XXI.

the undulations or flexures of the crust must be only temporary, and to account for their being rendered permanent, he introduces the notion of the curved portions breaking, and the molten matter being forced into these fissures, and thus bracing the flexures up into, permanent arches. A little further, however, when arguing "against the commonly received notion of the elevation and wedging asunder of the crust by intrusion of melted igneous matter," he contends, "that a fluid cannot act mechanically as a wedge." Now if this be true in one case, it surely must be equally true in the other; and therefore, the whole idea of permanency being given to such flexures by such means, falls to the ground; or, as the only other alternative, the commonly received notion is equally admissible with that of Professor Rogers.

But all these arguments are based on an assumption which we must examine a little more closely: namely, that these rocks thus twisted, flexured, and contorted, have floated on a fluid mass of molten matter. But how came they there? Does Professor Rogers suppose that these rocks are the result of the cooling down or congealing, as he calls it, of the molten mass, of which he probably conceives the earth to have originally consisted? On the contrary, he admits them to be mechanical and sedimentary rocks; they must, therefore, have been formed *from*, and deposited *upon*, previously existing solid materials. Where, then, are these? If they thus float on a fiery ocean, why have not the portions undisturbed, or at least so slightly disturbed, also been effected. That molten matter has existed there is clearly shown by the phenomena of the igneous rocks, but that these series of curved strata, extending for one hundred and fifty miles by one thousand three hundred, ever has floated on a sea of molten matter, (for to give the slightest colour of probability to the hypothesis, this sea of fire must have extended over the whole area equally,) is, I believe, a perfectly gratuitous assumption, for which we have no foundation whatever in geological facts. It must be remembered, that this is totally different from any abstract question as to the condition of the central portion of the earth's mass.

It may be asked, then, how otherwise can you account for such phenomena of twisting and curving; and for these phenomena following a definite law, as has been shown? Now, without at all admitting the justice of the reasoning, which would require us to

admit an explanation which appears physically improbable, because in the present state of our knowledge, we might not be able to offer a more satisfactory one, I still think that a little consideration of the ordinary forces which have been supposed to act in such cases, and of the mode in which those forces must operate, will explain many of the facts. It is not needful here, that we should enquire into the nature of the forces which have in such numerous cases exerted a powerful effect on the bedded rocks in the direction of the planes of bedding, or which, in other words, have produced lateral pressure. That such forces have acted, is granted by every one. All that concerns the present enquiry is simply, *granting the existence of such a pressure, what will be the results consequent on it in the mass of bedded rocks on which it acts.* But before discussing this question, there is one point to which it is needful to refer. Sir James Hall, who first pointed out by the simple experiment of layers of coloured cloth, pressed by a force from the side, the phenomena of contortion, seems to have been under the impression, that it was perfectly essential for the production of such foldings. that there should be a superincumbent weight, other than that of the atmosphere: and this has been again and again repeated by subsequent writers. Now any one who chooses to try the experiment, will most readily satisfy himself, that the presence of such a weight is by no means required for the production of flexures; it is only needed that the layer or layers should have a greater freedom to move in one direction than in another. This being the case, suppose a pressure applied at one end of such a series of beds, what will be the result? At first, compression only will take place; the amount of this compression depending on the original texture of the mass compressed. If the pressure be continued, the particles of which the mass is composed, having now been compressed into the smallest space which they can occupy, must move in some other direction; this direction being necessarily, in all cases of such rock compressions, upwards or outwards; (the point of the mass, relatively to the origin of pressure, at which such motion will first commence, will depend on many considerations, into which I shall not enter at present;) but it will clearly be, comparatively speaking, and under ordinary circumstances, near to the origin of pressure. Once diverging, these particles, and necessarily that portion of the mass formed of them, must follow the new direction which the particles have assumed;

that is, there must be a curving upwards in the mass. But while this curving proceeds to develope itself, the direct pressure or compression in the plane of the layers or beds is continued, and continued until the particles, in a more distant part of the mass, having been fully compressed, must, equally with the first, move in some new direction; and must, from the conditions of the problem, equally with the first, produce a tendency to curve upwards in the mass; this curve being necessarily developed in a line nearly parallel to the first. Such curves will be repeated with gradually diminished power, as we proceed further from the source of pressure. Now the particles or portion of the mass, thus moved from their position in the plane of the layer, having a tendency to move upwards communicated to them, have also their original motion, or a tendency to move onwards; they must, therefore, move in the direction of the resultant of these unequal forces, this resultant direction varying with the relative intensity of the forces; but in all cases having a tendency to make the particles move forward, or to make them over-ride one another; or in other words, to render the curves unsymmetrical, having an inclination forwards, or their "axes planes" directed *towards* the source of the pressure; precisely the fact observed by Professor Rogers; the amount of these flexures, their sharpness, and their inclination, will all vary with the intensity and continuity of the pressure.

But the limits of bending of such masses will soon be reached, and fractures must ensue; as a matter of necessity, these fractures will occur at the weakest point in the mass, or the points of least resistance; now *these points, in such a case, will clearly be the top or sharp bend of the curve towards the forward angle of it*, and *the bottom of the same limb of the arch;* (because here the two motions communicated to the particles will be most opposed one to the other;) but these are precisely the places in which Professor Rogers has shown that such faults occur; but which, even granting the origin of the flexures in waves such as he supposes, could not easily be accounted for on that supposition.

In all this, we have been considering the consequences resulting from the exertion simply of pressure, acting only in one direction; but this is not the case in such motions; as we have to deal with two forces, *one* acting in the direction of the radius of the earth, or tending to elevate simply; and the *other*, the consequence of

this, acting in the direction of the circumference; the resultant of these is, therefore, the true force which we have to consider; but this will only render the conclusions I have stated above more probable. It is extremely difficult,* without the aid of diagrams, fully to convey one's meaning on such a point; but I trust I have, at least in some degree, made myself intelligible. I shall in all probability resume the subject more in detail, at some of the meetings of the Society.

Professor Rogers has further applied the facts observed in the States, to account for the occurrence of cleavage. He supposes that each plicated belt of strata thus being the principal channel, through which molten matter and heated vapours passed, as being the most fractured and broken portion of the crust, there were formed thus alternate series of hotter and colder planes, exerting an agency analogous to a thermo-electric pile, and inducing those polarities of the particles, which Sedgwick and Herschel have thought the cause of cleavage. I would suggest further, that the motions which I have endeavoured to show must have resulted from the operation of a lateral pressure, will go far to account for those distinct cases of motion among the particles, which Professor Phillips first pointed out in 1843, and which Mr. Sharp has more recently attempted to reduce to rules, and also for many other phenomena connected with this very interesting question.

I may also refer to the law regarding cleavage planes, which I myself announced to this Society last year, as proved by researches in this country; that their dip in the main, corresponds, in its direction, with that of the planes of bedding of the rocks in which they occur.

But while we cannot admit the theoretical portion of Professor Rogers' valuable paper, we are greatly indebted to him for a clear and lucid enunciation of the facts of contortion, ascertained over a very wide area, and in a district where nature's works appear to be all moulded on a scale of grandeur unparalleled in the old world. What elevating conceptions of the mightiness of the forces called into play in the production of such phenomena as the geologist has to deal with, do we gain from an examination of districts such as

* A section illustrative of the structure of the district described by Professor Rogers, will be found in Lyell's Travels in North America, Vol. I. Page 92.

those described by Professor Rogers, where amid the unceasing variety, and apparently inextricable confusion, into which the rocks are thrown, we yet find all reduced to symmetry and law.

We pass now to the consideration of the additions made to our knowledge of the newer secondary and tertiary formations.

Mr. Ormerod has given an account of the great salt field of Cheshire, which is extremely valuable, from the amount and detail of the facts it contains; and as affording the only really valuable data we have yet had, for reasoning on the interesting question involved in the formation of these curious deposits.

The valuable memoirs of M. V. Raulin, on the geological structure of the Sancerrois, part of the old region of Berry, have been published, in which the most ample details of the mineral and lithological characters of the upper oolite, the greensand, chalk, and tertiary rocks of that district are given, and their parallelism with, and difference from, rocks of similar age in other districts, and the several elevations and disturbances to which they have been subjected, pointed out.*

M. Joseph Delbos, of Bourdeaux, has described in detail, the freshwater limestone of the basin of the Gironde, its peculiar character, and mode of occurrence along with the marine deposits of the same area. He describes the *molasse* as composed of alternations of clay, sand, and sometimes of limestone, the lower portion being principally clays, with occasional beds of limestone; above this, sands, with sandy clay, and, at top, thin clays. As regards the mode of accumulation of these curious deposits, the author advances the following opinions:—

1. That at the epoch, when the molasse was deposited, the eastern part of the basin of the Gironde was covered by a great lake, into which many considerable supplies passed, which, during the period of their greatest force, brought down sands, and even gravels. These supplies had their source in granitic countries, as all the elements of that rock are found in the molasse.

2. That when the force of these supplies diminished so far, that they could no longer transport even fine sand, then mud, more or less pure, was deposited.

* Mem. Geol. Soc. France, tom. II. page 2.

3. That at the same time a deposit of lime was taking place in the lake, more or less abundant, according to the time and place: when the force of transport of the supplies, from any local circumstances, became nil, then nothing but limestone was deposited.

4. That at certain times, and at certain places, within the area, siliceous and ferruginous springs supplied the elements, by which the rocks had been cemented.

5. That on the borders of this lake there existed plants and mammals, the remains of which were carried in by the water.

After some valuable details, the author concludes, that all the molasse deposits, and the freshwater limestone of the tertiary basin of the south-west of France, are above the parallel of the *calcaire grossier* of Paris; this latter being represented by the limestone at Blay, in the basin of the Gironde, which limestone is characterized by the presence of orbitolites; and he then proceeds to parallel the other groups with those occurring near Paris. This memoir is a valuable addition to the knowledge of the structure and arrangement of the tertiary rocks of France.

The "great question of the day," as M. Boué has denominated the disputed poin tas to the position of the nummulitic limestones of the Continent, has naturally attracted great attention during the year. And at the most recent meetings of the Geological Society of London, Sir R. I. Murchison, entered upon the question at large; and bringing to bear upon it his extensive knowledge of European rocks, has pronounced very definitely on the subject. In the first portion of his paper, which occupied two evening meetings, Sir R. Murchison entered on the question of the age of the "flysch," of the Swiss geologists, the "macigno" of the Italians; and confirmed the opinion, long before expressed by himself, that along the flanks of the Alps there was a real transition from the upper secondary to the lower tertiary. Where undisturbed, the rocks are quite conformable, and pass (as in the neighbourhood of Bassano) from true greensand, or neocomian rocks, up through the white scaglia or chalk, into the nummulitic and shelly deposits of the Vicentin, which are acknowledged to be of lower tertiary age. Other conformable transitions from the chalk or scaglia, into nummulitic rocks, are also pointed out; and it is concluded, that the whole group of the flysch and macigno, though frequently of very varied mineral aspect, (often a true greensand,) is in reality of eocene age. No separation of mem-

bers in the series can, in a district like this, be presumed from a local unconformability. In the succeeding portion of the same communication, the author devoted himself to establishing the age of the "molasse" and "nagelflue" of the northern Alps; and after detailing the numerous observations in the Alps, the Appenines, the Carpathians, and extending to Egypt and Hindostan, he concludes, by expressing his conviction, *that the great nummulitic formation is truly and exclusively eocene;* and that in no case does it form any portion of the cretaceous series.

This is by no means a novel result. Such was the opinion of many geologists, and the determination by Professor Edward Forbes, that the so called nummulites of America really belonged to another genus, orbitolites, removed some of the difficulty surrounding the question. Thus, in the communication made to the Society of Friends of the Natural Sciences at Vienna, we find M. Morlot, who had travelled through Illyria, for the express purpose of determining the position of this nummulitic limestone, relatively to the fucoid sandstone of Vienna and Trieste, and to the chalk limestone with rudistes, publishing in 1847 his conclusions, which, without entering into their detail, established the fact, that the nummulitic limestone was in all cases over the limestone with rudistes, or the chalk.* More recently, M. Victor Raulin, discussing the question not from his own examination, but solely from published facts, and viewing it in detail, both as regarded the evidence of fossils, and the evidence derivable from the theory of elevations, concluded that the nummulitic group belonged to the eocene period, and to the period of elevation of the Monte Viso system, of which the direction was N. N. W., to S. S. E.† In a subsequent memoir, he enlarged and corrected this classification, in which all the upper groups were equally given; but still he confirmed the position of the "*terrain a nummulites*" as eocene. The same author added much to the knowledge of local details by his paper, on the freshwater limestones of the Department de l' Aude;‡ and M. Delbos by his notice on the fahluns of the south-west of France, in which they are made miocene, and the nummulitic proup below them, lower miocene. M. Elie

* Rosthon arrived at different conclusions; Leonhard and Bronn's Jahrbuch, 1848, page 434.

† Bull. Soc. Geol. France, 10th January, 1848, page 128.

‡ Do. do. 19th January, 1848, page 428.

De Beaumont again, though placing all the nummulitic series in the eocene group, thinks, that with reference to its fossils, it may be divided into several groups.* Similarly we find Leymerie, D'Archiac, and Boué, contributing to establish the same facts. M. Hebert also by his papers on the deposits between the white chalk and calcaire-grossier of the Paris basin;† and still earlier, M. Roualt, in his careful description of the fossils from the eocene formation in the vicinity of Paris, have adopted the same views, all placing the nummulites in the eocene period. M. De Verneuil also had announced his conclusion, that no nummulites were found in the chalk series, but that they were all true eocene fossils.‡

But while the opinions of all geologists, who had examined the question at all, were centering on this solution, it yet remained for Sir R. Murchison to bring together all those local observations, and local conclusions, and uniting all in one, to state the general result, that all the nummulitic formations are eocene. This he has done with all that boldness of grasp, and generality of result which has characterized his former labours in geology, and he has unquestionably tended much to advance the progress of sound classification as applied to these rocks. It may, however, be fairly doubted, whether in this he has not in some degree, perhaps most correctly, outstripped his evidence, and drawn his conclusions more from impressions than from actual proofs. For instance, all the classification is based upon the supposition, that the scaglia can be fully and completely identified with the white chalk of England; for if the summit of the cretaceous system be not established, it is obvious that the base of the tertiary is equally uncertain, when the rocks form a continuous and conformable series. The fossil evidence is not yet made known—a few gryphææ are stated to be the only fossils common to the two groups, no *characteristic* fossils of the chalk being found in the nummulitic group: but what is a characteristic fossil of the chalk series. Is it one, which, in northern Europe and England, is confined to that series? But *here* it is perfectly established by natural history reasonings, that some considerable interval of time had elapsed, between the formation of the

* Bull. Soc. Geol. France, June 5th, page 415.

† Ibid, page 388.

‡ Bull. d l' Acad. Roy. De Belgium, tom. XIV. part 2, page 337.

uppermost beds of the chalk, and the deposition of the lower beds of the tertiary; and during this period, may not the organisms which existed during the period of the upper chalk in this country, have continued to exist elsewhere, and been entombed in the deposits then formed. Besides the same reasoning I have above expressed with reference to coal plants, is applicable here; and we would *a priori* argue that the existence of these nummulites, over such an immense area, is in itself sufficient reason to make us question the true parallelism *in time* of all the formations, in which they occur. I state these views simply, to express the caution, which it appears to me needful to use before admitting any such general conclusion, without sifting narrowly the evidence on which it is based, and not with the least desire of throwing a doubt on Sir R. Murchison's conclusions, which would certainly remove many of the difficulties which have surrounded this question.

M. D'Archiac, the first volume of whose valuable history of geology, was published during 1847, has announced* to the Geological Society of France, the conclusions at which he has arrived, from a general and comprehensive examination of the phenomena of the quaternary or diluvian formation, including in this term, all the phenomena, organic or inorganic, of which there are traces, between the termination of the subapennine period, marked by the elevation of the great chain of the Alps, and the existing epoch. He has compared all the materials published on this subject for the last twenty-five years for Europe, Asia, America, north and south, and Australia, and has concluded—

1. That the phenomena of striæ, and polishing of rocks, taken in the wide sense, have preceded all the deposits of this epoch; and consequently the development of the marine, terrestrial, and lacustrine faunæ. If these striæ, &c. have been produced by glaciers, the marine shells called arctic, which are buried in the clays and sands, which cover them, are not cotemporary with the period of greatest cold, inasmuch as they are found in the very places where these glaciers must have been. These shells, therefore, which point to a lower temperature than what prevails in the same latitude now, prove a more elevated temperature, than what prevailed in the epoch which immediately preceded them.

* Bull. Soc. Geol. France, 21st February, 1848.

2. The terrestrial fauna of large pachyderms, ruminants, and carnivora, was likewise posterior to the phenomena of the striæ, and in fact to the shelly deposits spoken of. The cause of the destruction of this fauna, therefore, could not be, as sometimes alleged, the low temperature which produced the greatest extension of glaciers. This fauna, so remarkable for the size and variety of the animals, has lived like the preceding shells, between the time of the striæ-phenomenon, or the period of greatest presumed cold, and the cataclysm which destroyed them almost simultaneously in Europe, Asia, America, and Australia.

3. If the erratic deposits which contain these bones, were carried by currents proceeding from the ancient glaciers, it necessarily follows, that these last did not belong to the period of the greatest cold; they must at that time have been confined to the mountainous regions, to allow of the growth in the lower portions, not only of the mammals but also of the vegetation on which they lived. There was, therefore, a sensible increase, or elevation of the temperature, after the period of the greatest cold, as represented by the striation of the rocks.

4. The first erratic phenomena would be exerted more particularly in the northern zone of Europe and America, and they would be more general; the second affecting more particularly the temperate regions of the two hemispheres, have been more subjected to local influences, and in many points have had two distinct phases.

5. After the phenomena of striæ, there was a sensible sinking of the coasts of many points; and later, at the end of the quaternary epoch, an unequal rising of the same coasts, varying in amount up to one thousand five hundred, or three thousand feet, and in few cases accompanied by dislocations.

The author finally concludes, that none of the hypotheses proposed to explain the phenomena of the diluvian epoch, is sufficient singly to account for the facts observed, but that they have concurred, either simultaneously or successively, in producing the results. All the proofs and details, in support of these conclusions, are promised in the second volume of M. D'Archiac's history of the progress of geology.

M. Boué has endeavoured to trace back from observed geological phenomena, the climatal character at former geological periods; he seeks to establish that the position of the isothermal curves in the northern portion of the two hemispheres, was very similar to

what it is at present, even so far back as the jurassic period. Of this he adduces as proofs—

1. That the erratic blocks come much further south in N. America than they do in Europe, and so do the isothermal lines.

2. In the old alluvial and tertiary deposits, fossils identical with, or analogous to each other, do not occur at the same latitude in Europe as in America, but always in more northerly localities, corresponding to the curvatures of the isothermal lines; thus the fossils of New Jersey are analogued in England, Paris, and north of Germany ; the fossils of the southern states are represented along the Mediterranean, and up to the middle of France.

3. Similar facts have been traced by Roemer, with regard to the cretaceous system ; thus the chalk rocks of Texas have the aspect of the chalk of the Mediterranean—the chalk of New Jersey that of the north of Europe.

Similar facts might be traced with regard to the northern limits of the nummulites from Europe, through Egypt to Hindostan ; and M. Boué concludes,* that however the temperature may have been higher for the earth, the same *comparative* climatal relations existed ; and shows the importance of such conclusions, in the bearing they have on some of the great questions of physical geology, the change in position of the poles, &c. &c.

Into what inexpressible littleness do the workings of man sink, when brought into comparison with the laws thus enunciated—laws called into operation countless ages before him, and which have held unshaken dominion, amid all the mighty changes that have since left their mountain traces on the earth.

M. Jules Grange has also discussed the effect of meteorological and geographical causes in modifying the former extent of glaciers.†

Mr. Strachey, in the journal of the Asiatic Society, Bengal, gives a very interesting account of the glaciers in the Himalaya mountains, and describes the features as identical with those observed in the Alps of Switzerland by Professor James Forbes. Alluding to the notices by other observers in other districts of the occurrence of glaciers, from one of which the Ganges springs, he concludes, that in the Himalaya, as well as in the Alps, there must be a large area covered by glaciers. We may, therefore, confidently look forward to a

* Bull. Soc. Geol. Trans. 3d April, 1848, page 276.

† Comtes Rend. 1848, page 384.

very large accession of our knowledge of glacier phenomena, when this magnificent range of mountains shall have been carefully investigated, by many of those able observers which the Indian staff contains.

The views of Professor J. Forbes as to the analogy which exists between the motion of glacier ice, and that of a semi-fluid or viscous mass, have received additional illustrations by the observations of Mr. Milward on an extensive mud-slide at Malta, read to the geological section of the British Association at Swansea. In this case, a large quantity of mud heaped up against a bank, began gradually to slide forward; it then divided, and the upper portion moved forward over the under. Regular bands were formed on the surface, presenting an appearance of difference of structure, being alternately fine and coarse—quite analogous to the so called dirt-bands of glaciers—these rough and smooth bands forming very distinct ridges, waves, or wrinkles, on the surface. Mr. Milward does not explain this phenomenon, although he altogether rejects any explanation derived from a consideration of the existence of a supposed alternation originally, of beds of different texture; this alternation, if existing at all, being the *effect* of the same force which produced the waves or wrinkles, and not the *cause*. Professor J. Forbes, in his fifteenth letter on glaciers, has given an interesting comment on these observations of Mr. Milward, pointing out the perfect analogy which exists between this wrinkling of the mud in the slide, and the production of the less and more compact wave on the ice, and stating his belief that the phenomena of ridges or wrinkles is a general one, depending on the toughness of a semi-fluid or semi-solid mass, forcibly compelled to advance or extend itself. Professor J. Forbes, also gives many other illustrations of a similar production of wrinklings in a mass of matter thus moved, as in the case of shavings taken off metallic surfaces by a planing engine, &c.; and shews that this is due to the same kind of motion to which he had previously attributed the similar phenomena of glaciers—namely, to that upward and forward motion which the particles must have assumed when compelled to move. This is a motion precisely analogous to what I have endeavoured to show, will fully account for many of the phenomena of contortions and curvatures of strata, as set forth by Professor Rogers, and appears to me, one of those striking instances, in which observations of existing phenomena throw important light on the explanation of phenomena of geological periods; and which compel

us to see the unity of the laws which control the operations of matter, even though it be so different in appearance and in structure as are the ice of a glacier, and the solid mass of a quartz rock.

I need not allude to the rapidity or generality with which, after the eloquent descriptions of Agassiz, many persons were induced to attribute to similar phenomena and at different periods, appearances which, in some degree, resembled those presented by glaciers in the country of Switzerland.

The mounds of gravel and heaps of sand which cover the surface of our country, were called moraines, our "diluvium," our drift, the huge boulders which strew our plains—all were ice-borne; and the whole surface, with the exception of a few isolated points of our northern hemisphere, was held to be at one time, covered with an almost unbroken sheet of ice. A little further research, however, shewed the futility of such reasoning in many, indeed in most cases, and other causes were seen to have played an important part in the production of these striking phenomena. The subject is, however, by no means exhausted, and observers in all parts of the world are bringing together data for the solution of such questions.

M. Guyot has long been engaged in the important investigation of tracing back to their parent source, the numerous varieties of rock found scattered over the great plains, and in the valleys of the glacier country of central Europe; and after a most careful and detailed search, has published his conclusions, which are sufficiently striking. He finds that not only is the erratic block formation of the Alps divided into certain groups or erratic basins, the limits of which are perfectly distinct; but that in each of these distinct basins, the distribution of the different rocks found in it, has been subject to definite laws; that this law has had the same influence in the plains as in the valleys, and that the law is the same in *all* the basins, however varied the rocks may be. Thus a particular kind of rock abounds, in one portion of the basin, but is found rarely, if at all, in another. And the blocks of different kinds, on leaving the place of their origin, have a tendency to form parallel series; and when they reach the plain, though they spread considerably, they still preserve a respective disposition, analagous to that which they originally occupied—the blocks derived from the right flank of the valley, occupy in the plain the right side of the basin, and those of the left flank, the left side; those derived from the more central valleys, cover

central portions of the plain. M. Guyot shows that this law of distribution is conformable to that which regulates the arrangements of moraines in an actual glacier composed of many tributaries ; and attributes this to the fact of the erratic blocks having been deposited by a glacier, which once covered the whole of this district. These results are certainly veiy remarkable, and there seems no reason to doubt the possibility of a sufficiently close identification of the rolled masses with their parent rock, especially in a district where the mineral character of the rocks is so marked, to admit of such a conclusion being justly drawn. That in each mountain-valley such a law of distribution should hold would be expected; but, that in the great plains, there should be even an approximation to such a law is an important fact. In connexion with the same districts as M. Guyot has made the particular subject of his descriptions, namely, the valleys of the Rhine and the Rhone, I would refer to a short, but very interesting paper read by Mr. Robert Chambers, to the Royal Society of Edinburgh, on the same districts, and in which, carrying out his favourite idea of the action of the sea at levels different from those it now occupies, he attributes many of the phenomena presented by the superficial deposits of these plains to such action ; and concludes, with remarking most justly, that "perhaps it would be well, if in scientific speculation, we were to keep our eyes more open than they generally are to diversified causes for similar or nearly similar effects."

It is to be regretted that Mr. Chambers has not more fully acted up to his own suggestion in the larger work which he has published during the past year, on " Ancient sea margins," in which a vast amount of detail is brought together, and a great accumulation of instances to prove, that all round our coasts, and in America, Norway, France, &c. there are unquestionable proofs in the existence of ancient sea beaches, that the ocean once stood at varied and different elevations above its present level up to fifteen hundred feet; that these margins or beaches preserve throughout a constant level, (though not always visible) for all parts of this area; and that therefore the change in relative level has been effected, not by an elevation of the land, but by a depression of the waters of the ocean —a depression taking place by sudden shifts at successive times, with intervening periods of rest. This is, I believe, briefly the object of the author. I shall not detain you by any recapitulation of

* Jameson's Edin. Journal, 1848.

the very strong evidence on which previous writers have grounded their opinions in arriving at a precisely opposite view, namely, that the level of the ocean was, and must have been, far more constant than that of the land, for these views may be found very fully and clearly stated in many works; but I would simply state, that evidence of an infinitely stronger kind, and based upon observations of a much more accurate nature than those of Mr. Chambers, must be brought forward before his conclusions can be admitted. A series of facts, or at least of statements asserted to be facts, based on observations of such a loose nature—frequently mere approximations derived from originally erroneous data—can never be admitted as evidence in cases where the matter to be proved is such a fact, for instance, as the occurrence of two definite lines of sea marking, or old sea-beaches, occurring at levels above the present level of high water, say at six hundred and eighty-seven, and seven hundred and three feet; and these determined in countries, separated by such an interval as Scotland and America. And yet, based on three or four observations of this kind, Mr. Chambers hesitates not to place some little ledge of superficial deposits, found in Scotland at half a dozen places, in exact parallel with those observed at Lake Erie, and to separate those occurring at the upper level, seven hundred and three feet, from those at the lower level, six hundred and eighty-seven, making them his two ancient sea-beaches, No. 33, and No. 34. This is a case taken at random from his book, but is, I think, amply sufficient to prove to any one who knows the limits of error of even careful levelling operations, unchecked by what are called tie-levels, that such loose and irregular determinations of level are utterly and entirely useless as a ground for any such conclusions as would establish a difference between two such bands at such distances, and the roughly ascertained difference of which was only sixteen feet in seven hundred. And this is by no means the strongest case that could be adduced. But Mr. Chambers has given us no clear notion of how he has in any case determined the question of what was, or what was not a sea margin. There are certain characters peculiar to a sea beach, not one of which he seems to have considered as necessary to be present; but he has, as it would appear—for he has not stated this clearly—considered that mere external outline has been sufficient at once to place all such flat topped accumulations of water-borne materials as he found in our superficial deposits in the

general category of ancient sea margins—with what justice any one, who has paid the least attention to such facts, can say. That the sea has exerted a long continued and powerful action on the solid rocks of the earth, at levels very different indeed from that which it now occupies, and even higher, comparatively speaking, than Mr. Chambers states, has been shown by many authors; and I have myself, laid before this Society during the past year, some interesting cases of this kind; but in all these cases, it has left undoubted marks of its presence. I may also be permitted to quote the words which I used several years since, (1844) in speaking of some of the very instances which Mr. Chambers quotes in our own neighbourhood, when I said, "that these deposits have been raised, is obvious; but that they are, or ever were *beaches*, is very questionable."*

I would also suggest to Mr. Chambers a careful examination of such facts as he will find represented by the excellent charts of our shores, published by the Admiralty. No fact is better known, than the large extent of ground covered by comparatively shallow water, which extends round all our coasts, and the suddenness with which the water becomes deep just beyond. A similar fact, Mr. Chambers will find repeated at certain intervals in such a way, that a section of the bottom would show definite portions of nearly flat sea bottom, and just beyond a sudden increase in the depth of water—this increase being of very varied amount. Now, let Mr. Chambers suppose all this brought up to view, or if he prefer it, suppose the sea removed from it, we would here have infinitely better and stronger evidence of a succession of sea margins or beaches, (if the form of the surface combined with the occurrence of marine remains, and the structure of the deposit be considered,) than any which Mr. Chambers has adduced; and yet, notwithstanding this apparent succession of beaches, there is not a single beach in the whole. This is one out of the many instances which might be quoted of the necessity which exists, before attempting to draw any induction from an accumulation of facts, to ascertain carefully whether these facts really belong to one and the same category.†

* Jour. Geol. Soc. Dublin, Vol. III.

† It would be foreign to our purpose to point out here, in any detail, how essential it is to prove that any "shelf" or "terrace" is of marine origin, or in other words, a "beach" or "sea margin," (for the words appear to be *assumed* by Mr. Chambers as synonymous) *before* speculating on the causes which have produced such shelves.

To Mr. Chambers, however, we owe much, for having brought the subject prominently before the public, and thus attracted increased attention to a series of phenomena of great interest and importance.

M. Omalius D'Halloy, in a note "*Sur les depots blocailleux,*" has proposed this name for all those deposits which contain a greater or less amount of angular fragments. These, according to him, are easily divided into two simple classes—one comprising brecciaform rocks; the other, in which the fragments are not, as it were, soldered together, but form a whole entirely composed of fragments. The author does not conceive it possible that the action of water has been the original cause of the production of these fragments, although subsequently it may have transported them; but that, in most cases, they were produced by the contractions of the mass, from desiccation or cooling, as in muds, &c., and this grand cause, aided by the disturbances which have taken place in the crust of the earth. The beautiful breccia of Tuscany (called the *Mischio di Seravezza*) in which angular fragments of white saccharine limestone, are tied together by a blueish paste of a pyroxenic character, forms a bed or portion of a bed between others of the ordinary saccharine limestone of the Apennines; and D'Halloy attempts to explain this phenomenon, by a reference to cases which sometimes occur in glass, where, resulting from a blow, or other such cause, we sometimes find a number of fragments enclosed in another portion, which remains unaffected: and he supposes that the matter which has filled in the cavities, has been injected from below in a state of igneous fluidity, and has, therefore, intruded itself into the bed which was fractured, but has not been able to force itself into those which offered greater resistance.

Another group of "*depots blocailleux,*" are those which accompany porphyries, basalts, &c. &c., and which the author attributes to the sudden cooling, and the consequent fracturing and breaking up of the outer coats of igneous rocks, and also the mechanical breaking of the same; the angular fragments thus produced being either again caught up in the fluid mass, or spread out in beds, more or less irregular, by the ocean. He then refers to a large class of rocks, puddingstones, &c.; and to account for the large amount of quartz found in them, the author has recourse to supposing the existence of siliceous springs, such as occur in Iceland, and which would deposit the

quartz; reasoning from the difficulty of accounting for the sources of this quartz, from any known deposits from which it could be derived. We have referred to this paper, as one among many instances in which the study of existing causes now in operation would readily have led the author to explanations very different, indeed, from those which he has given, and much more philosophically simple. The occurrence of such innumerable fragments of pure quartz in many of our conglomerates, has often excited the wonder of geological observers; but it is fully paralleled at the present day in the sand and gravel banks, which occur round our coasts. Take for instance the great deposits of sand in our own immediate neighbourhood, along the shores at Portmarnock, Malahide, &c.—sands, the composition of which would yield at least nine-tenths of pure silica in quartz grains. Whence, it may be asked, was all this derived? The rocks in the immediate neighbourhood are slates and limestones; and yet, although much of the quartz which enters into the composition of these sands may be derived from a distance, much has unquestionably come from the adjoining rocks. In looking at such results, as are now placed before our eyes, we are too apt to forget the necessity of tracing the successive steps in the processes leading to these results, as far as in our power; and thus we may omit to consider the facts that the accumulation of such heaps of silica is due to the circumstance, that the softer, and, therefore, more easily destructible, matter of the slates, &c. has been ground down, reduced to powder, and removed to a greater distance by the same forces, which have affected the quartz grains only to a slighter degree, in consequence of their more unyielding nature. And a close examination of even our fine sands, much more our coarser, will show that many of these grains of quartz are in some degree angular. It is indeed probable, nay, almost certain, that with quartz, and such other minerals, possessing great hardness, but at the same time considerable brittleness, the general mode in which masses are reduced to smaller grains, is by *fracture*, arising from the impinging of the masses against each other, and not by actual *wear*. In many cases, therefore, the comparative predominance of quartz fragments, in our old conglomerates and sandstones, is due simply to the fact, that the other and softer materials have been removed, while this has withstood the action of the agitating forces, which have distributed the masses.

Again, as regards those rocks in which the paste has a resemblance to, or is identical with, igneous products, the included fragments being also sometimes similar, although many facts, long since described by authors, attest the truth of the supposition, *a priori*, of D'Halloy, as to the breaking up of the surfaces of flows of molten matter, thus producing breccias, &c.; still we ought never to forget that in volcanic districts, at the present day, by far the greater portion of the mass of matter ejected, comes forth not in the form of couleès of lava, but as scoriæ, ashes and mud, and even frequently of perfectly formed crystals. Nor can we see any the slightest reason for supposing that the phenomena of older data were not similar; that we had not then, as now, showers of volcanic ashes, bombs, masses of rocks of various sizes, and flows of mud accompanying the exhibition of actually molten matter, and producing deposits originally similar to those now being formed in volcanic countries, but subsequently modified in appearance by infiltration, pressure, &c., and all the subsequent changes which have taken place. Our minds are frequently so much arrested by the striking and beautiful phenomena of dykes, and intrusions of igneous matter, at a period *subsequent* to the formation of the stratified rocks, with which they are associated, that we are too apt to forget that a similar exhibition of igneous matter may have taken place *cotemporaneously* with the mechanical deposition; and that thus we may have, and do have, igneous matter mixed up with the mechanical rocks, often in the most irregular and apparently arbitrary manner. Such cases, however, in no way compel us to seek for their explanation in intrusion, or forcible injections.

Connected with descriptive geology, I may refer to some communications to this Society, during the past year, which I had myself the pleasure of laying before you. In these I described, in some detail, the geological structure of the County of Wicklow, explained the mode of construction, and character of the map and sections illustrative of that structure recently published in connexion with the Geological Survey of Ireland, and pointed out their peculiarities. We have been enabled also to contribute from the labours of the officers of the Survey in other ways, as by M. Du Noyer's account of the very interesting section exposed at Fanghart, in the County of Down, where the phenomena of trap intrusions are so beautifully shown, and in which also the occurrence of the old red sandstone in that district was first made known.

But I allude to these communications for other reasons; for, arising out of some remarks at the November meeting of the Society, on the published sections of the Geological Survey, we had brought before us in December by Mr. Mallet, a full description of a proposition, (which he threw out as a suggestion in the first instance,) for the adoption of one uniform, and systematic principle, for laying down geological sections—a suggestion which appears to me of very great importance and value, and to which I must refer in a few words. Mr. Mallet stated very forcibly the objections to which the ordinary geological sections are open, and the uselessness of many of these for any purpose other than the mere illustration of some particular point of geological structure, and states his views as to what the real object of geological sections ought to be, namely, to give the physical features of the country correctly, and so lead to distinct ideas of the forces concerned in producing these—to give a true representation of the succession of strata; and further, to give economic information, such as relates to mines, agriculture, &c. These objects, Mr. Mallet believes, are not attained by the present system; and to accomplish such ends, he proposes, that all sections shall, in future, be laid down in lines due north and south, and east and west; or in latitude and longitude—that the several sections of the same district shall be laid down parallel to each other, and at equal distances apart, whether they be north and south, or east and west, the same horizontal and vertical scales being used, and half-tide level assumed as the datum.

When several such sections in both directions are laid down, they present a sectio-planographic, (to use an engineering phrase,) model of the district, and from such sets of normal sections any section in intermediate or diagonal direction can readily be inferred. As a brief mode of distinguishing such sections in description, the author proposes to call those sections which run north and south, or in latidude, *makrotome;* those passing east-west, or in longitude, *eurutome;* and these in any other direction in azimuth, *mesotome* sections. The author then concluded his communication, by briefly, but clearly and forcibly, pointing out the valuable results which might fairly be anticipated from the general adoption and completion of such a series of section for an entire country, and further for the whole globe; (his proposition essentially, including the idea, that such sections shall be continued across the sea, as well as the land;)

from the great geological features being brought into immediate co-ordination with the great cosmical forces which have tended to produce and modify these results. I must say I did not fully see the force of Mr. Mallet's suggestion thrown out as it was, in conversation, at our meeting in November; but having previously to the next meeting of the Society, at which he brought forward the matter more in detail, prepared sections on this general system of a portion of the County of Wicklow, from an examination of the sections of which the suggestion originated, I am fully satisfied that the method proposed is one of great value; and that a most important impulse would be given to the progress of physical geology, by the completion of such a series of sections. I have, however, some doubts as to the practicability of accomplishing it at present. There are few countries of which we have sufficiently accurate maps to enable such sections to be prepared, without enormous cost and trouble; for the British Isles—for Ireland especially, they could be made at a very trifling expenditure of either; but although it may require the lapse of years before geologists could, by possibility, be placed in possession of such sections for the globe, it would be extremely desirable that some such general system should be adopted, by which the labours of our fellow-workmen in all parts of the earth, could at once be brought into definite and symmetrical comparison, and by which the vast amount of research and toil now brought to bear on geological investigation, should be rendered useful, not only for the illustration of the detached districts examined, but as integral and definite portions of one grand system of illustration which should embrace the earth.

In the department of *Palæontology* we have, during the past year, had many additions to our knowledge, both of the peculiar forms of the fossil species, and of the laws which appear to have regulated their distribution at the period during which the rocks were being formed. To his valuable treatise, on the organization of trilobites, of which in 1846, the Ray Society issued an English edition, corrected and revised by the author, Burmeister has since added some important supplementary researches on these crustacea.*

During 1847, a work appeared on the trilobites of Bohemia, by

* D'Alton and Burmeister's Zeitung, 1848.

M.M. Hawle and Corda, but supposed to be almost entirely due to the latter author, in which the desire for genera-making has been carried to, if possible, a greater excess than ever. Nor can we omit to notice, in addition to the unsoundness of the author's views, the fact, that the book appears to have been an unjustifiable and unfair, because wilful, attempt to anticipate the labours of Barrande, whose treatise on the trilobites of Bohemia forms a very valuable addition to the knowledge of these interesting remains. In the Palæontological appendix to the descriptive memoir by Professor J. Philips, of the Malvern districts, drawn up in conjunction with Mr. Salter, some valuable additions to previous knowledge will be found.*

M. Alcide D'Orbigny has published his views on the classification of the very important group of brachiopoda. In his arrangement he adopts a dichotomous method, and therefore unavoidably brings together, or separates, the several genera into must unnatural groups. Mr. J. E. Gray has also† proposed a new arrangement of this important class. To Von Buch we are indebted for the earliest satisfactory illustrations of the fossils of this group, and subsequently the attention of many able naturalists has been directed to them. Mr. Gray's classification is founded on the character, position and arrangements of the oral arms.

Mr. Davidson has continued his very accurately drawn illustrations of the brachiopoda of the silurian system, in the Bulletin de la Societé Geologique de France, ‡a portion of which had been previously published in the London Geological Journal. In his present communication, we have accurate drawings and descriptions of twenty-five new species. In connexion with M. Bouchard Chantereaux, he has also§ illustrated very fully, by a beautiful series of specimens, the internal structure of the chalk fossil, originally named by G. Sowerby, *Magas pumilus*, and corrected several erroneous ideas concerning it ; and M. De Barrande has also continued his figures and descriptions of the silurian brachiopoda of Bohemia.||

Sir Philip Egerton ¶ has added to the knowledge of the fishes of

* Mem. Geol. Survey, Vol. II. part 1.

† Annals of Nat. History, December, 1848.

‡ Bull. de Soc. Geol. de France, 1848, 139.

§ Ibid, 1848, page 309, 8th May.

|| Haidinger's Naturwiss, Abhand, part 2.

¶ Quar. Jour. Geol. Soc. London, 1848, page. 302.

the older palœozoic rocks, by his description and figures of ptericthys, homothorax, &c.. Mr. Hugh Miller, universally known to geologists as the author of that delightful little work, "The Old Red Sand-stone," has continued his researches, and laid before the Physical Society of Edinburgh, some of his recent discoveries regarding the structure of asterolepis, dipterus, &c. The fossil fish of the same formation have received additional illustrations from Mr. M'Coy, our fellow member. He has added* three new genera, and twenty-one new species from this formation, (the old red;) and in another paper on fossil fishes from the carboniferous group, he has added to the already perhaps too large number, no less than eleven genera and forty-two species. As there are no figures of these species given, it is impossible to say how far the author is justified in such apparently minute separations.

In these papers, Mr. M'Coy has proposed a new family, the placodermi, and has pointed out a peculiarity in the formation of the tail, which peculiarity he has proposed to denote by the term diphycercal. We would thus have the homo-cercal, the heterocercal, and the diphycercal forms of tail, the latter characterised by there being, not only a spinal prolongation, but also, almost as great a development of the fin rays above as below the spinal prolongation.

Whether it be either desirable or needful to introduce new names for forms which appear to form only a passage or one step in a gradation between recognised types, must be decided by an examination of the specimens themselves, or of careful drawings.

H. Von Meyer, has given a useful summary of the fresh water fish of Bohemia, and the comparative species found at Gosau, Œningen, and other places.†

The fossils of the grauwacke formations of Thuringia, have been described and illustrated by Richter.

Our acquaintance with American palœontology, so far at least as concerns the older formations, has been greatly extended by the valuable and important work of Hall on the palœontology of New York. In alluding to this work, we must refer with great pleasure to the very splendid series of works illustrative of the Natural History of that State, published by the government of New York—

* Annals Nat. His. Nov. 1848, page 297.

† Leon. and Bronn's. Jahrbuch, 1848, page 432.

valuable from their detail, and important from the character and extent of the area which they illustrate. Since the earlier volumes on geology have been issued, great advances have been made in our knowledge of the silurian rocks in the old world, and Mr. Hall has fully availed himself of the increased resources placed at his disposal. Studying their own formations carefully, establishing their succession and relations, solely by a consideration of their true relative position, and other physical characters, and uniting with these enquiries, the careful and detailed study of the fossils contained therein, the American geologists have established for their own country, several distinct groups and subdivisions, which are in a great degree analagous to, or parallel with, those acknowledged in this country. I allude to this the more particularly as being an example of what appears the only true and sound method on which to conduct the geological investigatlon of any well defined district. It is only by seeking out the conditions under which, in that district, as compared with itself, the rocks have been formed that a knowledge of the successive modifications of those conditions, which have resulted in the successive formation of beds of varying lithological character, and containing remains of different and distinct organisms, can be arrived at. The attempt to force into parallelism with the subdivisions established in one country, those which may exist in another, and to found such conclusions on a comparison of a few fossils, or even a single fossil, (as has often been done,) found common to both, is unphilosophical and erroneous, and must inevitably result in, to a certain extent, concealing from our view the true nature of the problem. We cannot, therefore, too highly appreciate the independence with which the American formations have been studied, and compared one with another, and then, and not till then, compared with the known and established groups of other countries. In Hall's palæontology of New York, we have the results of such a comparison admirably brought before us in all its detail, and well illustrated. I cannot, however, enter into any detailed examination of this work, which is perfectly essential for the study of the silurian rocks of any country, and which will, therefore, be in the hands of many here.

We have had two important communications from Professor E. Forbes, before this Society, on the fossils from rocks of nearly the same age; one in which he pointed out the character and probable age of the fossiliferous limestones and slates at Portrane in this

county; and another, in which he describes a new genus of silurian or cambrian fossils, (*Oldhamia*) first made known by myself in 1844, as occurring in the very old rocks at Bray Head and other localities. I shall not here enter on the details of structure given by Professor Forbes, as the members will see all this in the Journal.

Passing from the older formations, Geinitz and Gutbier have given us a most important monograph on the fossils of the Permian system in Saxony, accompanied by excellent figures. This work fills up a blank in our science. Very few, indeed, of the organic remains of this group, containing the zechstein of German geologists, the magnesian limestone of our own country, and the rothliegende, have as yet been described. To Mr. King, of Newcastle, whose monograph on the magnesian limestone fossils of Durham, &c. is now passing through the press, for the Palæontographical Society, we are indebted for some—a few scattered notices have been given by others; and in Murchison's extensive work on Russia, several have been figured and described by De Verneuil. It was, indeed, from the great development of this group of rocks, in the district of Perm, that the name Permian was proposed by Sir R. Murchison, and has been very generally accepted. As the last stage of the palœozoic era, it forms an interesting series. The work of Geinitz and Gutbier, therefore, is a valuable addition on a much neglected portion of the stratified rocks. We would simply state the number of the several groups of which descriptions are given, which will suffice to show, that it is by far the best work on the fossils of the Permian system, we yet have—

Sauria	2	Radiata.	Echinodermata	1
Fish Ganoid	20		Crinoidea	2
„ Placoid	7		Polypi	8
Annulata	2	Plants.	Converfvæ	6
Moll. Cephalopoda	2		Equisetacea	1
„ Gasteropoda	7		Ferns	9
Conchifera	13		Algæ	6
Brachiopoda	16			

making a total of one hundred and one species.*

Professor Naumann has announced the discovery of the permian

* Die Versteinerungen des Zechstein, und Rothliegende, oder des Permischen systems in Sachsen, 1848.

system at Oschatz, and noticed the peculiar and distinctive character of its flora.*

In connexion with this, we may notice Von Buch's little treatise on the ceratites or ammonites of the Muschelkalk, which appear to be only eight in number, forming a remarkable group characteristic of that rock.

In the upper groups of stratified rocks, we have equally gained great additions to our knowledge of their fauna and flora. Giebel has contributed to our acquaintance with the corals of the planer-mergel.† Milne Edwards' valuable systematic treatise, on the same group of fossils, has been, in part at least, published.‡

Vicomte D'Archiac has given an able and beautifully illustrated report on the fossils of that remarkable bed in the chalk series, known locally to the miners under the name of *Tourtia*,§ and which forms a deposit of not many feet in thickness, extending over a considerable area, in the chalk series, which rests immediately on the carboniferous rocks of the frontier of Belgium and France. A close examination of these fossils shows that they form a remarkable group, the larger portion of which were previously undescribed. The author had pointed out some of these facts in 1839, but the detailed description is now first given. His carefully drawn up list is prefaced by some interesting and valuable general remarks; especially on the microscopic structure of the shells of the terebratulæ, which in this deposit have a prodigious development and very great variety. Out of forty-eight described, thirty-four or three-fourths are new, besides, at least, twenty distinct varieties. This genus also contains fully one-fourth of the total number of fossils of every kind. And M. D'Archiac thinks, that if future research should confirm these results, this thin and limited deposit will form one of the most remarkable examples of such phenomena known. Referring to the labours of Von Buch, Deshayes, Carpenter, Glucker, and Morris, on the intimate structure of the shell, he points out a new division in which small granulations in relief are observed on the folia of the shell, instead of the minute perforations or punctures pointed out by Carpenter; to this he applies the term *arenacees*.

* Bull. Soc. Geol. France, 8th May, 1848, page 301.

† D'Alton and Burmeister's Zeitung, 1848.

‡ Annales des Sciences Naturelles.

§ Mem. Soc. Geol. France, 2nd Ser. tom. II., part 2.

There is another and different structure in many of the ribbed terebratulæ, only visible under a high power, which he calls *fibro-capillaire*. M. D'Archiac, however, only states these results as provisional, and as very incomplete, but which, when carried out in sufficient number and variety, may lead to important conclusions. He points this out the more especially, as the consideration of these internal structures, has afforded to that able naturalist, Mr. Morris, the groundwork of his proposed classification of the terebratulæ.

Next to the terebratulæ, the most abundant fossils in the "tourtia," belong to trochus, turbo, and pleurotomaria, and with their associated remains would appear to me to point to a shallow water deposit. The great prevalence of terebratulæ in some degree militates against this notion, for as a group the brachiopoda are deep-water shells; but Mr. J. B. Jukes, in his interesting account of the voyages of the Fly, has noticed a similar abundance of terebratulæ in shallow water, on the coasts of Australia.

Mr. F. Pictet,* has published an important memoir on the fossils of the lower cretaceous group of the neighbourhood of Geneva, especially of those of the age of the gault; of this only the portion including the cephalopoda, has as yet reached us. It contains full and carefully compiled descriptions of seventy-eight distinct species, of which twenty-nine are now for the first time described, and illustrated by well-executed lithographs. Such local catalogues furnish the best possible groundwork for accurate reasonings on the distribution of fossils, and the physical conditions under which they existed; and this detailed memoir of M. Pictet will add considerably to the already high character which he has acquired as the author of the valuable "Traitè elementaire de Palæontologie."

The new species are thus divided—

Turrilites	1
Ptychoceras	1
Hamites	6
Crioceras	1
Ammonites	17
Nautili	3
	29

M. Nyst, to whom we are already indebted for several valuable

* Mem. de la Soc. de Phys. Geneva, tom. XI. 2nd part.

contributions to our knowledge of the tertiaries of Belgium, has undertaken* an elaborate synopsis of all the species, living and fossil, of the family of the Arcaceæ. The portion already published, contains only the genus arca properly so called, as defined by Nyst, a second portion being promised, to include the other genera pectunculus, nucula, &c., belonging to the same family.

M. Nyst includes, under the generic group of Arca proper, all the Cucullœæ of Lamarck and others; the Byssoarcæ of Sowerby, the Isoarcæ of Münster, Dolabra, and Crenella of M'Coy, and some seven or eight genera proposed by J. E. Gray in 1840 and 1847. Taking this extended view of the genus, M. Nyst finds that arca, of which Lamarck only gives forty-eight species, is in reality represented by four hundred and fifty-nine species, or subtracting from this eighteen uncertain species by four hundred and forty-one. In examining the distribution geologically of these, M. Nyst finds—

1. That the genus arca appeared with the earliest fossiliferous rocks, being represented in the lower silurian by two species;† in the upper silurian by nine; and in the devonian by thirteen—in all twenty-four.

2. In the carboniferous system by twenty-six, all of which belong to the lower portion of the system.

3. In the permian we have three species—

1 in the lower,
2 in the middle,
0 in the upper.

4. In the triassic group, the number of species again increases to twelve, all in the middle group.

5. The jurassic group contains sixty-nine, of which nine are in the lias—

20 in the lower oolite,
34 in the middle,
6 in the upper.

6. That the cretaceous group appears to be that which contains the largest number, having in all one hundred and ten species, thus distributed—

27 in lower,
11 in middle,
63 in upper.

* Mem. de l' Acad. Roy. de Belgium. tom. XXII.

† To these we must add some since described, as *arca primitiva*, Phillips, Mem. Geol. Sur. Vol. II. part 1, page 366, plate XXI. 5, &c.

7. In the tertiary group we have ninety-six species, of which there are—

41 lower,
25 middle,
30 upper.

8. That the genus has acquired its maximum development in existing times, being represented by one hundred and two species, which, as regards geographical distribution, are thus divided—

27 in northern ocean,
93 in tropical seas,
7 in southern,
35 precise locality unknown.

This distribution is also remarkably definite, as only five are known to pass from one zone to another, viz.—three *(Arca, barbata, diluvii, lactea,)* from the northern to the equatorial, and two *(Arca, corbicula, semitorta,)* from the equatorial to the southern.

The subdivision of the genus pointed out by Mr. M'Coy, (Dolabra) is found confined to the lower palæozoic rocks, *(depots de transition.)* Cucullæa appears with the same group, and is there represented by ten species, but attains its maximum development in the cretaceous group, where it has thirty-nine representative species, and gradually dies out as we approach the existing period, as it has only five species in tertiary rocks, and two living. M. Nyst further asserts that no one species passes from one great group to another; that of the whole number only nineteen—which he considers have not been sufficiently examined, or identified—pass from one system to another, and that out of the whole number of living species, only thirteen have been found in the upper tertiary rocks.

The value of such a careful resumé of all published species, and the importance of such publications in detail, cannot be too highly estimated. It must be borne in mind, however, that such a synopsis, however accurate at the time of its publication, is liable to constant change, as our knowledge of the subject may increase; but its real importance consists in the facility it affords, and the inducement it offers, to the student to study and compare his own experiences with the records and observations of others, so as to confirm or modify their results, and so tend to eliminate errors, and attain a more perfect knowledge of the laws which regulated the distribution

and development of such organized creatures, at successive periods of the earth's history. While, therefore, we cannot agree with M. Nyst in some of his conclusions, as depending on identifications or distinctions, which we would not acknowledge, we recognize the value of his paper, and look forward with anticipation of results of equal interest to the publication of the second portion, containing the other genera, belonging to this family.

The same author has given a similar synoptical and systematic list of the genus Crassatella,* accompanied by a description of two new species, (C. astartiformis, and C. Bronnii,) both from the lower tertiary group.

Lamarck in 1818, described only nineteen species, including five now belonging to the genus *mesodesma*. M. Nyst's table shews seventy-one. Of these the geological distribution is as follows :—

Lower cretaceous,	5
Upper do.	17
Lower tertiary,	24
Upper do.	4
Living,	19

All the living species belong to warm climates, not one is found passing from the fossil to the existing period, nor is there one of the living species found fossil: further, not one is found common to any of the two systems.

Michelotti's† beautifully executed and accurate figures of the miocene tertiary fossils of North Italy, although published in 1847, may be noticed, and Heer's‡ description and plates of the insect remains found at Œningen and Radobog, in Croatia. M. J. Bosquet§ has described a new species of Hipponix from the chalk at Mæstricht, *H. Dunkeriana*, the first as yet known from that formation.

Mr. M'Coy has also given us a useful list of the mesozoic radiata, which he has been able to recognize as occurring in British strata, since the publication of Morris' most valuable list of British fossils. To the list of known species is prefixed a description of thirty-eight new species from the chalk and oolite formations, and one new

* Bull. de l' Acad. Roy. de Belgium, tom, XIV. part 2, page 116.

† Descr. des foss. des terrains miocene de L'Italie septen.

‡ Die Insekten fauna der Tertiargebilde von Œningen, und von Radobog in Croatien.

§ Bull. de l' Acad. Roy. de Belgium, tom. XIV. part 2.

genus, diplopodia. The grounds of these distinctions cannot be fairly estimated until Mr. M'Coy may favour us with accurate figures of the new species.*

As bearing on the same point, we may here allude to Mr. Lycett's excellent communication on the distribution of the fossils in the neighbourhood of Minchinhampton, in which much useful information is given. It is somewhat remarkable, and must have occurred to every one engaged in such enquiries, to find the very small number of the oolitic fossils which have been figured and described in Great Britain. Rich in most beautifully preserved specimens of almost endless variety, with its several subdivisions for the most part well marked and easily accessible, it is certainly rather surprising to find that the very series of beds which formed the groundwork of the important discoveries of Mr. Smith, and which may, therefore, be considered as classic ground in geology, should have received so little attention. We, therefore, hail with pleasure any contribution to our knowledge of their organic contents.

Mr. M'Coy has more recently† given a complete list of all the palæozoic corals and foraminifera he has observed from British strata. In this paper he has made eight new genera, and fifty-five new species, of corals, and one new foraminifer. Here, again, we have a series of names without any sufficient illustration, and we are, therefore, at a loss to know what value to attach to such distinctions. I have already in the address, with which at the request of the Council I opened the present session, insisted on the very injurious effect which such hastily compiled, and insufficiently illustrated lists have on the progress of our knowledge. To this paper, however, Mr. M'Coy has added a list of great value to Irish geologists, as it contains the localities and formations from which the specimens described and figured by him in the valuable synopsis of the carboniferous fossils of Ireland, published by Mr. Griffith were obtained. This list to a considerable extent supplies the deficiency so much felt in the Synopsis; but we are quite sure we express the wish of every one who has had occasion to consult Mr. Griffith and Mr. M'Coy's work, when we would earnestly urge Mr. Griffith to give to the public a more complete

* Annals. Nat. His. Dec. 1848.

† Annals Nat. His. Jan. and Feb. 1849.

and detailed description of these localities, and of the subdivisions he has established in the carboniferous group

Dr. Reuss has also given a splendidly illustrated memoir on the fossil polypiaria of the Vienna tertiaries,* which is an extremely valuable addition to the knowledge of fossil corals.

During the past year, in addition to the valuable papers, in the second volume of the memoirs of the Geological Survey, by Professor Forbes, the structure of the Pentremites has been illustrated by the discovery of F. Roemer,† who has found in specimens from Alabama, that the ambulacral pores were not orifices for the passage of membranous tubes, serving as organs of locomotion and respiration, as in the Echinida, but alimentary canals for a corresponding number of articulated tentacula, formed in the same manner as the arms of crinoids, shewing that these pentremites are true crinoids, and do not approach to the Echini. Mr. Yandell has made the same observation in Kentucky specimens, *(P. florealis.)*

Professor E. Forbes was led to a careful examination of the same group, while investigating the structure and analogies of the cystidea, and his conclusions, drawn from a much more general and higher consideration, than those of Roemer and Yandell, will be found, at length, in his most important paper, "on the Cystidea," (Mem. of Geol. Sur. vol. 2, part 2, page 523, &c.)

M. Pomel has established, after a careful investigation, the range of the Mastodons. He finds that the M. *angustidens* is confined, with the M. *buffonis*, to the pliocene rocks: M. *cuvieri* and *tapiroides* to the miocene. In Europe they are exclusively tertiary upper and middle. In America they are found with the remains of Elephants, (E. primigenius) in diluvium.‡

We must not omit a notice of Bronn's Index Palæontologicus, a general list of fossils with their synonyms, well executed, and very useful to students.

The Palæontographical Society, established (on principles similar to those which were found to work so successfully in the Ray Society,) for the publication of works illustrative of the palæontology of these countries, has, during the past year, issued its first volume, containing

* Haidinger. Naturwiss. Abhand.

† Bull. de la Soc. Geol. France, 1848, 17th April, page 296.

‡ Bull. Soc. Geol. France, 1848, 20th March, page 258.

the first portion of a monograph on the fossils of those British tertiary formations, known under the general name of the Crag. This portion includes the univalves only, and in it we find descriptions of two hundred and fifty species, illustrated by upwards of five hundred figures, engraved by G. B. Sowerby, jun. These, although by no means engraved in the best style, are amply sufficient for the identification of the species, and are accompanied by full and careful descriptions, by Mr. Searles V. Wood, whose catalogues of the fossils of this formation, published in the Annals of Natural History for 1840-1842, furnished the first general list which British geologists possessed of these remains. Mr. Wood has continued his researches up to the present time, and availed himself of all the aid which the labours of others in the same field could afford; and we thus have the history of these fossils brought up to the latest date, by one who has long and successfully laboured in the subject. Although not more than a few new species have been added, (ten or eleven,) still the great advantage of such a work consists rather in the facility of study it affords to the collector of such remains, and the obvious result which such a means of easy comparison must produce in tending to advance our knowledge of similar deposits. The great difficulty of identifying fossils, from the numerous works, detached, and frequently difficult to procure, which must be consulted, and the time which such a system of comparison necessarily occupies —time and labour, infinitely greater than any one who has not been actually engaged in such investigation could suppose—have constantly proved a bar to such studies; and we, therefore, have great pleasure in the prospect which the publication of such a series of monographs, as shall for the separate groups of fossiliferous rocks in the British Isles, bring together and arrange all the existing knowledge, and place it before the student in a condensed and easily accessible form affords. The various monographs furnished to the Society by authors distinguished for their devotion to such pursuits, promise to form a most valuable library of reference for the British student of Palæontology.

The beautifully illustrated work of our colleague, Dr. Harvey, on the British Algæ, which at once combines the most careful scientific descriptions and analyses of the species, with attractive notices of their habits and uses, continues to add to his well earned and high reputation, and proves useful and interesting, as well to the scientific algologist, as to the mere collector of our sea weeds.

During the past year, another group of our algæ has been brought before our notice in the treatise by Mr. Ralfs, on the British Desmidieæ. Long known by his able papers on this subject, read before the Botanical Society of Edinburgh, and published chiefly in the Annals of Natural History, (many of the illustrations and descriptions contained in which have since been appropriated by others) Mr. Ralfs has in the present work brought together and wrought out the entire knowledge of the subject up to the present time. The work is amply illustrated by plates of exceeding beauty and unequalled accuracy; the species are fully described; the microscopic structure accurately explained, and the actual measurements of the object in all cases given, (a novel and very valuable addition in such treatises.) In the introduction Mr. Ralfs discusses at length the question of the Animality and Vegetability of these organisms. The former view, supported by Ehrenberg, had been the prevalent one, but Mr. Ralfs, after a candid and manly discussion of the arguments on both sides, appears to have established the conclusion, that the Desmidieæ, must be regarded as "Algæ allied on the one side to the conjugatæ, by similarity of reproduction, and on the other to palmelleæ, by the usually complete transverse division, and by the presence of gelatine.* This work is of direct interest and value to geologists, from the occurrence in many places, and in some quantity, of fossil Desmidieæ, or portions of Desmidieæ. Thus Mr. Ralfs shows, I think, conclusively, that "the orbicular spinous bodies so frequent in flints are the fossil sporangia of Desmidieæ," pointing out the errors of Ehrenberg, in referring them to fossil Xanthidia.† Fossil fronds also of Desmidieæ have been found by Professor Bailey, in calcareous marls brought from New Hampshire and New York.‡

We cannot, however, consider that Mr. Ralfs has performed more than half his task, until we are favoured with a similar volume on the allied group of the Diatomaceæ, (of much greater interest and importance to the geologist;) and we hope that the universally expressed pleasure with which his present volume has been hailed,

* Ralfs Brit. Desmidieæ. Intr. page 36. Mr. Thwaite's valuable paper on the Diatomacea, and more resently on the Palmelleæ may also be referred to. Annals Nat. His. Nov. 1848.

† Ibid. page 12.

‡ Silliman's Amer. Jour. Vol. XLVIII. 340.

will encourage him speedily to accomplish its conclusion. That he has continued his researches in a similar direction, is shown by his recent communication on the mode of growth of Oscillatoria, and allied Genera, (Annals of Nat. History, January, 1849.) Mr. Dickie has described the occurrence of a considerable group of nearly forty diatomaceæ in the fossil state, in marl from Peterhead, Aberdeenshire.* And Mr. Williamson has described in detail, many diatomaceæ occurring, in abundance, along with other interesting microscopic objects, in the mud of the Levant.†

Ehrenberg also has continued his microscopical researches, and described the remarkable infusoria found in the stomach of a Peruvian freshwater fish. Previously he had examined several hundred fish, and very rarely had traced an abundance of infusoria in them; but this fish had a large amount (thirty-one species are given,) showing that it had lived on an infusorial mud.‡

In connexion with fossil botany, the most important contributions of the year have been the papers by Dr. Joseph Hooker, published in the memoirs of the Geological Survey of Great Britain, in which an able comparison of the flora of the carboniferous period with that of the present day is given, as well as a valuable resumé and discussion of our knowledge as to the nature and affinities of those remarkable vegetable fossils, called lepidostrobi. To these researches of my colleague, however, I cannot do more than allude, merely recommending the philosophical and exquisitely illustrated paper of Dr. Hooker, to the careful study of all interested in such enquiries.

M. Ch. Martins§ in a memoir on the vegetable colonization of the British Isles, Shetland, Faroe, and Iceland, after recapitulating and fully admitting the facts on which Professor E. Forbes founded his conclusions, in the very original and suggestive paper, "On the connexion between the distribution of the present fauna and flora of the British Isles, and the geological changes which have affected their area, &c., takes exception to the causes to which such facts have been referred, and seems to think, that oceanic currents, the action of winds, and the migration of birds, are quite sufficient to account for the phenomena. Without referring to the

* Ann. Nat. His. August, 1848.

† Mem. Lit. and Phil. Soc. Manchester, Vol. VIII. new series, 1848.

‡ Ann. Nat. His. June, 1848, 465.

§ Bibliotheque Univ. June, 1848.

all important fact, that in this case M. Martins has altogether overlooked, or at least omitted, the consideration of terrestrial or land animals; (although he admits the remarkable fact of their very peculiar distribution also,) I would simply remark, that the currents of the ocean to which he refers, chiefly naming the *gulf-stream*, would have just the opposite effect to that which he would attribute to them; its direction *in the main*, after it reaches the shores of Great Britain and Ireland, being *towards* and not *from* the south. It is quite impossible, therefore, to refer to its agency the transport of seeds from southern Europe. If the first origin of some of our plants were due to such agency, they should rather be Mexican and American plants than Portuguese and South-European plants; but they are in reality the latter and not the former. Again, the action of winds in transporting seeds is unquestionably considerable; but if they had been really the cause of any large portion of our flora, we should naturally, and I think justly, expect that (*cæteris paribus,*) the majority of those plants should be plants derivable from those countries from which the prevalent winds blew; now the prevailing direction of our winds is known to be from the south and west, while the *prevailing* character of our flora is *Germanic*, or of that type which is derived from, or at present characteristic of, countries lying just in the opposite direction. It would, therefore, appear to me, that while perfectly agreeing with M. Martins on the necessity of attributing their full value and importance to the agency of existing causes, we yet are compelled to believe that those causes, united with others, perhaps more important, have acted under such different circumstances, that we may justly admit the conclusion of Professor Forbes, and see that recent geological changes *have* left their traces in the peculiar grouping of our fauna and flora.

We may here allude to the very interesting fact, that since the date of Professor Forbes' paper, several plants have been added to the list of those already known in Ireland; and that these have all, in a most remarkable way, borne out his views. These discoveries have been made known by Dr. Harvey during the past year.*

* Thus, Dr. Harvey has announced the discovery of *Simethis bicolor*, *Kth.* found May, 1848, abundantly, on hills, and by the seaside, in peaty and in sandy soil, near Darrynane Abbey, by Mr. Thaddeus O'Malley: native of Portugal and shores of Mediterranean, not cultivated in Irish gardens. *Saxifraga andrewsii*, *Harv.*, remarkable new species, with the flowers of *S. nivalis*, and leaves resem-

In addition to the published contributions to our palæontological knowledge, I may add, that in a communication from Mr. Binney of Manchester, recently received, he states, that he thinks "he has found good evidence of reptilian remains from the British coal measures"—a very interesting and important addition, and confirmatory of recent discoveries on the Continent. Mr. Binney also writes, "that during last Autumn, in company with his friend, Mr. Rcbert Harkness, of March Hill, near Dumfries, he found the track of a new species of Rhynchosaurus in the Bunter Sandstein, in several quarries near Dumfries. The footmarks are very different from those of Corncockle Moor, described by Dr. Duncan:" and further, he has been pursuing the study of the Lepidodendra and Sigillaria, a subject on which we are already deeply indebted to Mr. Binney; and, after a good deal of cutting, has obtained a beautiful transverse section of Lepidodendron, showing clearly, that this plant had not only a vascular cylinder round the pith, but one also just under the bark, inducing Mr. Binney to think that the *Sigillaria elegans* of Brongniart, is nothing but a *lepidodendron*. I shall do nothing more than announce these interesting facts, waiting for the detailed publication of them by Mr. Binney.

Mr. J. M'Adam of Belfast, who has for some years been zealously bringing together a very large and valuable collection of the greensand fossils of the County of Antrim, is at present engaged in their examination, and hopes to be able to make known some of the results soon. He has found no representative of the lower greensand in that district.

I cannot leave the subject of palæontology without directing your attention to an important lecture delivered by Professor E. Forbes, at the beginning of last year, at the Royal Institution, London, on the question, whether genera have, like species, centres of distribution. Professor Forbes in this lecture carried out, and extended some views which he had previously announced with regard to distribution. Every *species* was shown to have necessarily occupied a single area, (however that area may have been subsequently broken up into detached portions,) within which there is some point or centre where that

bling those of the Swiss species, allied to *S. pyramidalis*, on Clune Mt. near Glen Cara, Kerry, found by Mr. W. Andrews. *Erica ciliaris*, Linn. found near Roundstone, Galway, by T. F. Bergin, Esq. 1846, growing with E. Mackaii in abundance, in flower in September.

species had its origin. Now the enquiries of zoologists, of botanists, and of palæontologists, all tend to show that in a similar way, groups of species or *genera*, occupied definite areas in geological space, as they did in geological time. Of this Professor Forbes gave numerous instances, both from the animal and vegetable kingdoms, instances in which this distribution could not be governed by elemental conditions. So far as research has gone, it would appear that each genus has occupied a definite *area in time*, which area in time is unique for such genus, apparently pointing by analogy to the inference, that where there is an apparently *double* area occupied by a genus in space, these double areas are only parts of a single area, now divided. Thus establishing the idea of areas of genera as to space, Professor E. Forbes discusses the question, whether such areas had centres—or in other words, points of maximum and points of origin; and shows the probability of such being the case, and of the point of origin of a genus being also its point of maximum, and possibly also of its final disappearance. The important effect which such enquiries must exert in influencing the philosophical study of palæontological phenomena, is too obvious, to need that I should insist upon it.

The important and complicated subject of volcanic action has, during the past year, received much attention. M. Perrey,* to whom we were previously indebted for several contributions to what may be called the statistics of earthquakes, has published a detailed and valuable catalogue of all earthquakes, which are recorded to have taken place in the Italian peninsula, from the fourth to the nineteenth century; or more particularly, from the year 325 to 1849, giving a total number of recorded shocks of one thousand three hundred and sixty-two. In reducing the results, of these laborious searches through the very many works and journals in which the records have been found, to the tabular form, the author has here, as in his former memoirs, considered all shocks, or commotions of the earth, which disturb the same country, during a greater or less period of time, but continuous for that period, as forming one single phenomenon—considering as *one* single shock, all the continuous shocks united which may have occurred in one and the same place, without an interval of more than eight consecutive hours, during one

* Mem. Couronnes, de l' Acad. Roy. de Belgium, Tom. XXII.

month: where they have been continued for more than one month, he takes one for each month; considering, however, as distinct those shocks which have affected distant localities, though nearly at the same time.

Tabulating in this way all the shocks noticed in the Italian peninsula for the period mentioned above, by months and by centuries, he finds the relative proportion for each season to be as follows:—

Winter, (January, February, March,) 359—Spring, 314—Summer, 265—Autumn, 284. For the six months, from 1st of October to 31st March, 650—from 1st April to 30th September, 581, being nearly the ratio of ∷ 9 : 8.

From this it appears that Winter preserves for the Italian peninsula, the preponderance which M. Perrey had already shown that it held in other physical regions of Europe. Autumn, however, instead of being second, has become third, in the order of frequency of earthquake shocks; Summer being here, as elsewhere, the least fruitful in subterraneous movements.

The author had previously found, in all his investigations of a similar character for the rest of Europe, that the number of the shocks for the six months from October to March, as compared with the number for the six months from April to September, had a ratio of 4 : 3—the present numbers give a ratio 4.5 : 4. Tables of the relative frequency of these for each month, and for separate periods, are also given. Out of the total number of one thousand three hundred and sixty-two, the direction in which the motion took place is only recorded for one hundred and sixty-three cases; discussing these few, however, as regards their direction, we find the following results:—

From North to S.	21	S. to N.	22
N.E. to S.W.	22	S.W. to N.E.	11
E. to W.	39	W. to E.	18
S.E. to N.W.	24	N.W. to S.E.	6

In taking the opposite directions together, that is, those from north to south, and those from south to north, and similarly with regard to the others, we have—

N. to S. and S. to N.	= 43	1.05
N.E. to S.W. and S.W. to N.E.	= 33	0.80
E. to W. and W. to E.	= 57	1.39
S.E. to N.W. and N.W. to S.E.	= 30	0.73

which would give the relative proportion nearly, as shown in the column above. From these numbers, and considering the cause of the movement, whatever it may, as in a certain degree proportioned in intensity to the number of instances in which each direction has been observed, these relative numbers may be considered as representing these forces, and thus we can determine the mean resultant direction of the movements. This the author has done, not only for the Italian peninsula, but also for the other well marked physical regions of which he had discussed the earthquake phenomena, and he tabulates the result. He alludes to the interest which such results have, taken in connexion with the the orographic and hydrographic systems of the districts given. We may mention one or two. Thus for the basin of the Rhone the mean resultant direction is south, 9° 44′ west; which is also as nearly as possible the mean direction of the river; similarly with the Rhine, south 7° 9′ east; for the Italian peninsula the mean direction given is, south, 72° east, also the mean direction of its mountain chain.*

M. Perrey has equally published the results of his researches as to the earthquakes which have affected the Iberian peninsula, and also gives a list of these recorded generally for the year 1847.† Of these there were ninety-one; out of this number only sixteen, scarcely more than one-sixth, have their direction recorded; and the descriptions of most of them are excessively meagre, and in some cases even unintelligible.

Of the peninsular earthquakes, records are given from the earliest years of the eleventh century down to 1844. The total number recorded is two hundred and twenty; taking these by seasons, as before, and omitting nineteen, of which only the annual date is given, we have for—

		Relative numbers.
Winter,	55	1.09
Spring,	41	0.82
Summer,	46	0.91
Autumn,	59	1.17

and taking, as before, the monthly mean as unity, the relative value

* The numbers given above are not the same as those given by M. Perrey in his tables, because I have embodied the additional information contained in his supplement.

† Bulletin de l' Acad. Roy. de Belgium, 1848.

for the seasons would be as shown above; or grouping the seasons, we would have for the six months from October to March, one hundred and fourteen; from April to September, eighty-seven, numbers which are also very nearly in the ratio of 4 : 3, as the author had obtained before from the rest of Europe. For France proper, the ratio was found to be as 3 : 2. Discussing the shocks, as regarding the direction in which the movement took place, he gives the relative numbers for each direction, and deduces from these the mean resultant direction of the motions for the Iberian peninsula to be east, 31° 56′ south.

M. Perrey very justly remarks, that on these results no great reliance can be placed; and points out very strongly the necessity of more careful observation, not only of the shocks themselves, but of the numerous phenomena accompanying them, thermometric, barometric, or meteorological, &c. In fact, what first and most forcibly arrests the attention in looking over the notices which M. Perrey has, with such labour and care, brought together from all the scattered records at his disposal, is the total absence in most cases of any notice of those very elements in the observations, which are essential to a proper study of the facts. I have already noticed the very small number in which even the direction of the movement is given; but this is not all—we have no record of the amount of this motion—no trace of the variation in this amount, if any—no notice of whether any permanent alteration in physical features of the district resulted—in few cases even a notice of the time of occurrence. It was, perhaps, scarcely to be expected that in the earlier ages such accurate accounts should be given, as would suffice for the present demands of science; but the same absence of any useful observation arrests our attention in looking over the records for 1847, and almost in as great a degree as in those for the tenth and eleventh centuries. We become—as we study such meagre accounts, in many cases given by persons perfectly incapable, from want of proper knowledge, or from the exaggerations of terms, to record with accuracy even what they may have observed, or to notice the facts which are essential to the correct knowledge of the cause of these striking phenomena—we become, I say, more and more convinced of the absolute necessity for adopting some well devised scheme of self-registering instruments to record the principal points connected with such phenomena; and we cannot but refer with great regret to the

somewhat extraordinary and unusual withdrawal by the British Association, or rather by the Committee of Recommendations of that body, of a grant which they had sanctioned during the previous year for the preparation and establishment of such instruments. I trust, however, that our last President, Mr. Mallet, who has already thrown so much light on the question of earthquake action, will still be enabled to carry out his ingenious scheme for such instruments.

But slight as is the scientific value of results deduced from such imperfect premises, as those which M. Perrey has found himself obliged to use, he has contributed essentially to the advance of knowledge on such subjects by the summary he has given. And his numerical results, drawn from instances so great in number, and extending over so large an area, and possessing such a regularity and constancy in their ratio, do seem to authorize a conclusion, that the circumstances of surface temperature, as shown by the variation of seasons, have some influence in the production of, or in affecting the causes tending to produce, such phenomena. And are we not by this fact almost unconsciously led to trace some new intimate connexion between the exhibition of such forces, and of volcanic action in general, and the great pervading magnetism of the earth. And is it too fanciful to suppose, that here, too, a new link in the chain, which so closely unites the great cosmical forces, may be rivetted, and that heat and electricity shall be found reciprocally to produce and to result from earthquake motion, or what we call earthquake motion; and that the laws which are known to regulate the direction of magnetic currents, may prove the key to a knowledge of the laws which have controlled the direction of volcanic forces on the earth's surface?

As bearing on volcanic action proper, we have obtained, during the past year, in Dr. Daubeny's second edition of his history of volcanoes, the most complete and perfect synopsis of facts, and the best guide for the student desirous of obtaining a knowledge of these interesting and intricate phenomena. Dr. Daubeny has, during the time, now some twenty years, which has elapsed since the publication of his first edition, seen no reason to alter his views as to the cause of volcanic action; and he still strongly and ably supports the so-called chemical theory. His work, however, is much more valuable as a summary of facts connected with the history of volcanoes.

Dr. Daubeny, incidentally in his treatise, has put forward a new

method of accounting for the long disputed question of the dolomization of certain limestones in the neighbourhood of igneous rocks. After alluding to the views often propounded, as to these igneous rocks being the source from whence the magnesia has been derived, he points to the many known and described cases in which peculiar ingredients have been determined to particular portions of the mass, and molecular changes have taken place in a rock without actual fusion; and asks, "May we not suppose, then, this same segregation of parts to take place in limestone rocks likewise? and may not the magnesia, previously disseminated through an extensive formation, be determined to particular layers, during the long continuance of a heat inferior to that which would be required to fuse the limestone, or to obliterate the traces of organization present in it? If so," he continues, "the existence of dolomites may be connected with the presence of an igneous rock without deriving its magnesian constituents from the latter source, and possibly the higher temperature of those portions of the limestone, which lay nearest to the source of heat may, by enhancing the affinity subsisting between the carbonate of lime and carbonate of magnesia, favour the formation of dolomite in those parts more particularly."* He thus looks on dolomization as only a peculiar case of metamorphism.

In connexion with this subject—one which has already received considerable illustration by the valuable analyses by our member, Dr. Apjohn, published in our journal—I would refer to a short, but interesting memoir on the geology of the island of Bute,† by another member of our Society, Mr. James Bryce, jun., in which, after a clear description of the general structure of the island, and a notice of some of the more remarkable points, he details the phenomena which occur at the contact of greenstone and limestone, where a dyke of the former traverses the limestone at Kilchattan. "Its direction," Mr. Bryce says, "is very nearly that of the dip, and the effects are well seen at the eastern side of the quarry. Along the plane of contact, the limestone is altered to the state of a granular saccharine marble, which, on the application of a slight pressure, crumbles into a fine powder. This is suceeeded by a hard crystalline marble; the crystals appearing in distinct plates. Between this and

* Daubeny on Volcanoes, second edition, page 708-709.
† Proc. Phil. Soc., Glasgow.

the last (? first) change, which is one of simple induration, there are many gradations." He proceeds to state, that similar effects are common, and notices the occurrence of magnesia under such circumstances, the simple carbonate of lime of the unaltered limestone becoming the double carbonate of lime and magnesia. And referring to the entertained views of geologists on this point, he states the results of an analysis of two specimens, one of the saccharine marble in contact with the dyke, the other of the unaltered limestone. The remarkable result was, by a rough analysis, that the unaltered limestone contained about thirty-four per cent. of magnesia, but the altered rock had not three per cent; while the presence of a silicate, probably silicate of magnesia, was indicated by the gelatinous paste of silica, obtained on treating the powdered rock with hydrochloric acid. Mr. Bryce asks, then, what has become of the magnesia? Has it been driven off by the heat to which the limestone has been exposed, and refers to the statements of Dr. Apjohn, which point out that this could in all probability not be the case; for a much lower heat than would be sufficient to expel the magnesia, would cause the silica to enter into composition with it, and form a silicate. Mr. Bryce has promised a complete series of analyses of the limestones, both altered and unaltered, of Bute, for the results of which we look forward anxiously.

But, however important the influence of igneous rocks may be in some local cases of dolomization, the numerous instances in this country and elsewhere, where we find thick and *continuous* beds of dolomitic limestone associated with, and regularly interpolated among other beds of simple carbonate of lime, totally preclude the possibility of applying such theories to explain their production. We might quote here the words of our colleague, Dr. Apjohn, read so long since as 1838, when—in alluding to the theory proposed by Dr. Scouler at that time, that the magnesian character of such masses was caused by the infiltration of magnesia dissolved in water charged with carbonic acid—he says, "I would merely suggest, as an extension of this hypothesis, that as many limestones contain a small quantity of magnesia, their conversion into dolomites may sometimes be accomplished, *not by the addition to them of magnesia, but by the removal of carbonate of lime.*"* The importance of a

* Jour. Geol. Soc., Dublin, Vol. I. page 375, &c.

careful examination of such rocks by analysis is evident from the unexpected results obtained by Mr. Bryce.*

M. De Beaumont in 1837, in a remarkably interesting notice on the formation of Anhydrite, gypsum, and dolomite,† pointed out some of the results, as regarded volume which would ensue from the supposed change of the simple carbonate into the double carbonate of lime and magnesia. Taking the equivalent of carbonate of lime as 632, and of carbonate of magnesia as 535; and supposing the dolomite represented by the formula $\left.\begin{matrix}\frac{1}{2}\,\dot{C}a\\ \frac{1}{2}\,\dot{M}g\end{matrix}\right\}\ddot{C}$, we will see that any cubic contents of limestone thus altered, will be reduced in bulk in proportion to these numbers, but will have the increased density of the mixed salt (2.88,) this decrease in bulk being in the ratio of 1000 to 882, or about twelve per cent. of the total volume of the rock so altered. And M. De Beaumont pointed out the important bearing of this consideration, as explaining the cavernous structure common in dolomitic limestones.

These notes of De Beaumont have led M. A. De Morlot, at Vienna, actually to measure the proportion between the cavities in such rocks and the total volume. He took an average specimen of the grey crystalline dolomites of the southern Alps, and calculated carefully the volume of all the spaces, as compared with the total volume of the specimen; the proportion was found to be 12.9 to the 100—a result remarkably consonant with the theoretical result of De Beaumont, and quite within the limits of error, which we would naturally suppose should result from the employment of a single specimen of such small size, as compared with the great masses it was taken to represent. Now the fact of many corals being thus found in the state of cavernous dolomite, although preserving all their organic forms, shows clearly, that the peculiar character and composition is the result of a change which has taken place subsequently to their fossilization, and therefore, that the atoms of lime, replaced by the magnesia, have been removed and disappeared. What, then, have been the phenomena of this alteration,

* While speaking of dolomites, we would take the opportunity of referring to an elaborate history of dolomite, considered mineralogically, by M. Fournet, published in the Annales de la Soc. D'Agric, Lyons.

† Bull. de la Soc. Geol. France, Tom. VIII. page 177.

and what the chemical reaction? Haidinger, who has long studied these facts, having noticed them in the Transactions of the Royal Society of Edinburgh, in 1827, has been led, by his examination of the phenomena, and the remarkable connexion which frequently exists between gypsum and dolomite, to suspect that the magnesia had been brought in the state of sulphate of magnesia, a salt very common, abundant in some mineral waters, and even in the waters of the ocean; that this sulphate, in decomposing, had reacted on the limestone, so as to alter it into dolomite, by producing a double decomposition, resulting in carbonate of magnesia and sulphate of lime. We know, however, that an opposite decomposition takes place, and that sulphate of lime in solution, filtered through dolomite in powder, for a sufficient length of time, changes it into carbonate of lime, and forms sulphate of magnesia. Now Haidinger has observed the efflorescence of sulphate of magnesia in the quarries of gypsum. He noticed that the *Rauchwacke* was the result of a change of dolomite into carbonate of lime, by a gypseous solution, accompanied with a formation of sulphate of magnesia; and studying the peculiar relations under which the hydrated oxide of iron occurs, he is clearly of opinion, that this peculiar chemical reaction, the cause of what M. De Morlot calls *dedolomization,* has only taken place under small pressure, and at a low temperature, as in the laboratory. But on the other hand, taking the peculiar circumstances of other beds of dolomite into account, Haidinger was equally led to suspect, that although, as at ordinary temperatures, and under the ordinary atmospheric pressure, the sulphate of lime (gypsum) will decompose dolomite, so as to form carbonate of lime, and sulphate of magnesia, still under a considerable pressure, and at a higher temperature, just the opposite action would take place, and that then sulphate of magnesia would decompose limestone, and form dolomite and sulphate of lime. Having no index to the temperature which had existed at the time of the formation of these dolomites, he estimated, from the acknowledged increase of temperature as we descend, and the probable thickness of the beds, that a temperature of about 200°, corresponding to a pressure of about fifteen atmospheres, would be sufficient. Then mixing the atomic proportions of sulphate of magnesia and carbonate of lime, he subjected them to this temperature and pressure, (in a gun barrel) and found the double decomposition took place completely, and the double carbonate of lime and magnesia,

and the sulphate of lime formed.* These results are undoubtedly of great value; and it is not improbable that from the facts first stated by Elie De Beaumont, the presence or absence of a cavernous structure in a dolomitic limestone, may tend to a knowledge of the circumstances under which it was formed; while a consideration of Haidinger's results, in connexion with the peculiar relations of the beds or masses, may determine the conditions, as to temperature and pressure, under which this alteration has taken place.

I have dwelt much longer on this subject, than I otherwise should, from the interest which it possesses to the student of Irish geology, whose researches will make him acquainted with magnesian limestones of every kind, and occurring in every possible variety of position.

Other classes of alterations in the mineral structure of rocks have received attention, and have been elucidated by several observers during the year. M. Delesse has published in detail,* a continuation of his valuable memoir on the mineralogical and chemical constitution of the rocks of the Vosges, in which he describes, with great accuracy and skill, the composition and character of the Ternuay porphyry; having devoted the former portion of his memoirs to the porphyries of Belfahy and other points, and pointed out the great importance of studying chemically and mineralogically the unstratified rocks, and the mechanical deposits in connexion with them.

With this view, M. Delesse has examined the several constituent minerals of the porphyries, carefully separating each from the mass, and also the mass of the rocks in which they occur. And in the continuation of his memoir published last autumn, he follows up similar enquiries with respect to the porphyry of Ternuay. This had previously been classed by all geologists as a common variety of porphyry or of diorite, excepting by Mr. Cordier, who had recognized its distinctness, and given to it the name of Ophitone. Felspar of a greenish or slightly blue tint, having a more fatty lustre than ordinary felspar, forms the paste of this porphyry. It decomposes on the surface with a red tint, and forms a kaolin, as does the Belfahy porphyry. M. Delesse says it is remarkable that the felspars most poor in silica, (such as labrador, anorthite, &c.) and those which are

* A. De Morlot, Sur le dolomie, Bull. Soc. Geol. France, 1848, page 243, Haidinger, Naturwiss: Abhand.

† Annales des Mines, Tom. XII. part 5, page 283.

attacked by acids, resist this change into kaolin; while on the contrary, the orthose, albite, and andesite, varieties, which are rich in silica, and are very slightly attacked by acids, change readily. The author describes at length the physical characters of this mineral, and its chemical composition, action before the blowpipe, &c. &c.

During the process of these analyses, finding constantly an amount of loss, he was led to suspect that this felspar contained a certain marked quantity of water of combination; and uniting this fact with others which he had previously pointed out, he concludes, that spite of its easy volatilization, water plays an important part in some felspars and rocks, usually considered of igneous origin; and that although this may appear paradoxical at first, it is easy to account for it, by supposing sufficient pressure; besides the fact of the presence of water is not in reality much more extraordinary than the presence of potash or soda in the same minerals or rocks, since the hydrates of these bases would be volatilized at a much lower heat, than would reduce the rocks to a fluid state. He shows that when water enters into combination with these felspars, it gives to them peculiar characters. They have a fatty lustre, and waxy fracture; the specific gravity is greater than that of the varieties which do not contain water; they have ordinarily a green colour, which, although never observed excepting when oxyde of iron or manganese is present, is still clearer, richer, and more beautiful, in proportion as the water of the combination increases.

Now all these felspars are similar crystallographically, only presenting some slight differences in the facility of cleavage, and are therefore isomorphic; but isomorphic minerals can be represented by the same general formula, and this, therefore, ought to be the case for felspars. Our knowledge of the laws of polymeric isomorphism is too slight as yet to admit of this; but if we grant the remarkable hypotheses of Dr. Scheerer, as to the mode of substitution of water as a base, we arrive at results of great simplicity. In this way the analyses of the mineral in question would give the proportions of oxygen in the bases as in the ratio of 1 : 3 : 5—a proportion which no known felspar up to that time had exhibited, and comparing it with labradorite and anorthite, it would appear to make a middle term, and fill up the gap.

To this variety M. Delesse gives the name of Vosgite, from the mountains in which it occurs.

In another and distinct notice of the orbicular diorite of Corsica,* the same author states that the felspar in it has a specific gravity of 2.737. nearly equal to that of labradorite and anorthite in general, but less than that of Ternuay: it is crystallized in the sixth system. A careful analysis showed that it approached in character to Vosgite, but contained three parts less lime, much less alcali, and but little water of combination; to this small amount of water is its low specific gravity to be attributed. The proportions of oxygen in the monatomic bases is, however, as 1 : 3 : 5 : the same ratio as in Vosgite, of which this mineral is only a variety; taking the general formula, therefore, we have for these felspars, the following:—

Labradorite,	$1 : 3 : 6\ r\,Si^3 + Al^3\,Si^3$
Vosgite,	$1 : 3 \,.\, 5\ r\,Si^3 + Al^3\,Si^3$
Anorthite,	$1 : 3 : 4\ r\,Si^3 + Al^3\,Si^3$

Reverting to his memoir on the Vosges rocks, we find that he has examined the augite, which forms the other principal ingredient in the porphyry, with equal care, and shown that it also contains water of combination to the amount of 2.75 per cent., and that the clearness of its green colour varies in proportion to this amount of water. Other minerals, which are only occasionally present, are noticed also, as iron pyrites, magnetic iron, quartz, epidote, &c.

Having thus examined in detail the constituent minerals, the mass of the rock was subjected to equally careful analysis and examination, and its several marked varieties described. The loss by heat of these is given; and however the external lithological character varied, it is remarkable, that the amount of this loss scarcely varied at all, giving an average of 3.0 per cent. After discussing some methods of obtaining the general density of the mass, and from this a knowledge of the relative proportions of the several constituents, and then to calculate "from this" the elementary composition of the mass, he finds that this porphyry of Ternuay, when well characterized, contains an amount of silica equal to that of the felspar and augite, which form its constituents, but that it has less of alumina, less of alcali, and generally less of water than the felspar alone, but more of protoxide of iron, of lime, and magnesia.

* Comptes Rendus, October, 1848, page 411.

The average composition of the normal type of the rock is—

Silica	49
Alumina	24
Oxyde of Iron and Manganese	3
Lime	8
Magnesia	6
Soda	4
Potash	3
Water	3

In his notice of the orbicular diorite of Corsica* he states, that calculating the atomic volumes of felspar (vosgite) and hornblende which form this rock, he finds that these volumes have to each other the simple proportion of 4 : 3, and that this law appears to apply to all varieties of diorite, melaphyre, pyroxenic porphyries, euphotides, &c., and in general to all rocks of an igneous origin composed of two elements, of which one is crystalline felspar of the sixth system, the other a silicate of iron and magnesia of the fifth system, such as amphibole, uralite, pyroxene, augite, hypersthene, diallage.

Having thus completed his analyses of the igneous rocks, he proceeds to discuss the changes which have taken place in the adjoining schists which have been elevated by them. This metamorphism is only on a small scale, not extending more than three yards from the mass; but taking four specimens at different distances, the furthest from the igneous mass representing the unaltered condition of the schists, and that next to the mass, the most altered, he finds by careful analysis that the density of the rock increases as we approach the igneous rock from 2.743 to 2.852—that the amount of lime also increases; and he shows most clearly, that this results from an actual transfer of a portion of the elements of the porphyry into the slates, by which, in these slates, crystals of vosgite are formed, crystals of a mineral which could not otherwise have been formed in the slates, as the elements which enter into its combination do not therein exist.

The porphyry thus so carefully described by M. Delesse, is worked for ornamental purposes, and has been selected to form the base of the monument to the Emperor, in the Hotel des Invalides.

On the same district—one rendered classical in the history of

* Comptes Rendus, October, 1848, page 411.

geology by the labours of many able investigators, but the rich stores of which are not even yet exhausted—we have a most interesting digest of his observations, by M. Fournet.* Directing his examination only to the eruptive rocks and the metamorphic phenomena, he scarcely enters on the question of the succession of the sedimentary rocks. The eruptive rocks consist of granite, syenite, porphyry, diorite, &c., all of which are well described. The metamorphic phenomena are then passed in review. The principal results of the action of the granite is the production of micaceous schists; as a subordinate effect the change of schist into schistose diorite, or greenstone, of which there are stated to be very clear examples—the development of crystals of sahlite, amphibole, mica, sphene, &c., and, remarkably enough, the production of noble serpentine in the middle of the calcareous beds, which M. Fournet states is also clearly a metamorphic result. The porphyries have hardened, rendered prismatic, fused or semifused the slates, which pass into hard compact or granular pastes of a greenish colour and euritic, generally having small crystals of felspar. Many of these distinct porphyries are described, and the reasons fully stated for supposing them to be the result of alterations in the bedded rocks, and not to be eruptive. M. Thuria had previously suggested that many of these porphyries, which were jointed, and had a certain amount of schistose structure, were in reality eruptive, having been poured out cotemporaneously with the deposition of the mechanical rocks; but this notion M. Fournet combats. He also describes the melaphyre rocks of Oberstein, so famous for their agates, and enters fully into the question of their origin.

Subsequently taking up the question of alteration generally, and pointing out the reciprocal or mutual action which has taken place in most such cases of alteration, he distinguishes the two results. Thus retaining the general term metamorphism, as applicable indifferently to modification of the igneous or of the sedimentary rocks, he proposes to apply the term *exomorphism* to those particular cases in which the sedimentary rock has been changed, or when the alteration has been *outside* the source of change; and the term *endomorphism* to those cases in which alteration has taken place within the rock itself; and thus he would speak of endomorphic and exomorphic rocks, &c.

* Annales de la Soc. d'Agric de Lyons, Tom. X.

Fournet's paper, although on the same district, differs most materially from that of M. Delesse, to which I have before referred, in the absence of those accurate and detailed numerical results which form the great value of the latter; but it is characterized by broader and more general views, and is of great interest to the Irish geologist, as bearing on alterations, most of which are perfectly paralleled in this immediate neighbourhood; although we cannot agree with him in several of his conclusions, as for instance, his rejection of Thuria's opinion, that many of the porphyritic rocks of that district may have been cotemporaneous with the sedimentary, a fact which we see so abundantly illustrated in our own land: still it forms a valuable and important contribution to our knowledge.

I have given a more detailed analysis of M. Delesse's short paper, than perhaps the limits of this address would fairly permit; but I have done so, because it is one of the few papers to which we can point, in which there is that union of accurate analysis, with careful examination in the field, so entirely requisite for the full or trustworthy examination of such subjects. During the past year, in a communication which I myself laid before this Society, touching on the question of metamorphosis, as exhibited in the county of Wicklow, I ventured to express opinions very similar to those of M. Delesse, regarding the actual transfer of some of the elements of the igneous rock—in this case granite—into the slates adjoining; and I also gave you several instances of changes similar to those alluded to by M. Fournet, in which we have largely crystalline greenstones, unquestionably the result of an alteration induced in originally laminated schists; and when some analyses at present in progress shall have been completed, I hope to find results very similar to those which he has given. I would also point to the almost total absence of such examinations in these countries, as an additional proof of what I have frequently insisted on, viz., that too great tendency to overrate the importance of fossil remains, and in consequence to neglect the study of those great masses in which no trace of organized life exists. As far as fossiliferous rocks are concerned, unquestionably the importance of such evidence as the remains of animals entombed in them afford, if rightly interpreted, can scarcely be overrated; but it must be borne in mind, that these rocks form only a portion, nay only a small portion, of the earth's crust, and that, therefore, for all the remaining portions such researches are useless. I think it an

error which cannot be too strongly or too frequently protested against, the allowing a student to suppose that the mere knowledge of the external aspect of some ten or twelve minerals will suffice him for his geological pursuits. And although, as a necessary result of the accumulation of knowledge, a division of labour has ensued, and many have devoted themselves to one portion of such enquiries, and many to others, still all are so intimately linked, that success in one cannot be looked for, or at least commanded, without something more than a mere general or superficial acquaintance with the others. But I have already, in the remarks with which, at the request of your Council, I opened the present session of the Society, endeavoured to impress on you the injurious effect, which a partial cultivation of any portion of our subject has produced, and is calculated to produce.

The Society will remember perfectly the very interesting communication of Dr. Apjohn, in 1847, on a Hyalite from Mexico, in which he found much less water than in the described species, and pointed out the remarkable optical properties possessed by it. The researches of M. Damour* on the siliceous incrustations of the Geysers, have an immediate connexion with the same subject. Following up his enquiries on the thermal silici-ferous waters of Iceland, he has submitted to analysis the siliceous matter deposited by these waters; and which he denotes by the general name Geyserite. This substance occurs in concretionary masses, white, greyish-white, or occasionally tinged with red. Its structure is cellular, sometimes scaly; in parts it is quite transparent, and has a vitreous fracture. Some few specimens present very beautiful opalescent tints of blue and green, but only retain this property while moist; if exposed to dry air, the opalescent portion falls to powder. Experiments showed that the silica was in some molecular condition which rendered it easily attacked by alcaline mixtures, and besides, as it dissolved in carbonate of soda much more easily after calcination than before, it appeared that the expulsion of the water modified the molecular condition, and consequently that a portion of the water was in a state of combination. Exposed for a long time to an atmosphere of dry air, it loses more than two-thirds of its water; while, on the other hand, if exposed in an atmosphere saturated with

* Bull. de la Soc., Geol. France, 7th February, 1848.

moisture, it absorbs a sensible quantity of water. A portion of the mineral previously calcined and powdered, was heated to boiling for five hours, in a concentrated solution of carbonate of soda and sulphur in excess; the liquor became coloured of a yellowish brown tint, with a slight smell of sulphurous acid; at a temperature of 70° cent: the liquor remained transparent, but became milky on cooling, and the silica was thrown down in plates; on heating again, the transparency was restored, and these phenomena were repeated, as often as the temperature was raised or disminished. It appeared, then, that the presence of sulphur in excess determined the separation of silica from an alcaline solution, so long as the temperature was under 70° cent: A careful analysis showed the presence of minute portions of lime, alumina, and soda, and traces of potash in the substance. And M. Damour thinks that this discovery of the presence of an alkali may afford a clue to the knowledge of the origin of several deposits of amorphous quartz, its presence serving to point to an origin analogous to that which the Geysers now present. Viewing, then, Geyserite as an hydrate of silica, he was led to comparative analyses of the minerals of the same group, such as opals, resinites, and hyalites. The results are all carefully detailed, and he finds, that in addition to the three known artificial hydrates, there are four natural hydrates.

Opal of Mexico, Geyserite,	$HO + 3\,SiO_3$
Opal of Hungary,	$HO + 2\,SiO_3$
"Silex resinite" of Mexico	$HO + 4\,SiO_3$
Hyalite	$HO + 6\,SiO_3$

To these we must add the hyalite of Mexico, described by Dr. Apjohn. The opal of Mexico, and the Geyserite, were found to be identical in composition, and this opal was also very hygroscopic, a specimen which, when freshly cut, was quite transparent, becoming soon milky and dull.

These results of M. Damour are peculiarly interesting in connexion with the researches of Bunsen, Descloizeau, &c., and are another of the many important results which have sprung from the scientific expedition to Iceland. It is to be greatly regretted, that M. Damour did not submit his specimens to careful optical examination, so that their internal structure might be compared with that described by Dr. Apjohn.

In the first volume of the publications of the Cavendish Society, we have, during the past year, had a translation given of a most important memoir from the pen of Professor Bunsen of Marburg, which originally appeared in Liebig's Annalen: bd. lxii. 1847. Full, accurate and complete, as has been every thing emanating from Professor Bunsen, this memoir, "On the pseudo volcanic phenomena of Iceland," recommends itself particularly to geologists, by the important bearing which many of Bunsen's conclusions have in explaining some interesting, but hitherto not fully understood, facts in geological history. In strict accordance with the principle on which I have intended to act in selecting matters for observation, namely, to confine myself exclusively to communications published during the past year, I should omit any notice of this valuable paper; but as it has only become known to the English reader within that time, I may very briefly allude to some points in it.

One of these, of some interest, is the conclusion to which Professor Bunsen has come, with regard to the origin of the Muriate of Ammonia, which is so common a product in volcanic countries. Contrary to the views of other writers, he believes that ammonia, nitrogen and their compounds, although so frequent an accompaniment of volcanic action, "belong originally to the atmosphere, or to organic nature," "and are foreign to the actual source of plutonic activity." He supposes that the sal ammonia, is due to the action of the flows of heated lava, upon vegetable substances, with which they have come into contact at the earth's surface, and gives a very strong confirmation of this view in the circumstances accompanying the flow from Hekla in 1846. Here the lower portion of the lava stream was, for some months after the eruption, studded over with little fumeroles, in which an amazingly large quantity of crystallized muriate of ammonia was found; but this formation of sal ammonia was entirely confined to that portion of the lava flow which had passed over meadow land; higher up and nearer the summit, where vegetation ceased, the formation of this salt equally ceased, the large fumeroles there yielding only sulphur, muriatic, and sulphurous acids, but no trace of ammonia. But by much the most important portion of the memoir, relates to the remarkable phenomena of decomposition, which the rocks exhibit under the influence of the acid gases and thermal waters of the volcanic district. The effect of sulphurous acid on the prevailing rock of the

district, a palagonite* tuff is traced out: the resulting formation of sulphuric acid and of sulphates; the oxide of iron being originally dissolved, as a sulphate of the protoxide; and these acid solutions being neutralized by their further passage through the rock, this oxide of iron is again thrown down as hydrated peroxide, or sesquioxide. "The decomposed palagonite is thus converted into alternate and irregularly penetrating beds of white ferruginous and coloured ferruginous fumerole clay," (p. 334.) Professor Bunsen remarks, that one is astonished at observing the great similarity existing between the external phenomena of those metamorphic depositions of clay, still in the act of formation, and certain structures of the *keuper* formation. A similar action takes place with regard to the sulphates of alumina, the formation of gypsum being a main product. And here, again, it is said, "we can scarcely avoid the conviction, that the origin of a portion of the vast deposits of gypsum, which so frequently characterize the marly argillaceous strata of the later floetz series, and in which the total absence of calcareous conchylia points to the action of acid vapours, is due to a chemically identical, but, perhaps, geologically different action; and Professor Bunsen

* Palagonite (from Palagonia) is the name given by Baron Waltershausen to a mineral noticed by him as abundant in Sicily, and of which the composition is as follows:—

Silica,	37.417
Sesqui-oxide of Iron,	14.175
Alumina,	11.165
Lime,	8.766
Magnesia,	6.036
Potash,	0.685
Soda,	0.652
Water,	17.152
Insoluble residue	4.108
	100.156

leading to the formula—

$$\left.\begin{matrix}\dot{M}g_3\\ \dot{C}a_3\\ \dot{K}_3\\ \dot{N}a^3\end{matrix}\right\}\dddot{S}i_2 + 2\left\{\begin{matrix}\dddot{F}e\\ \dddot{A}l\end{matrix}\right\}\dddot{S}i + \dot{H}$$

or in general terms—

$$\dot{R}_3\,\dddot{S}i + 2\,\dddot{R}\,\dddot{S}i + 9\,\dot{H}$$

alludes to the value of a careful investigation of these deposits, with a special reference to their natural relations. The important difference in the results depending on differences in the gases evolved is also pointed out; thus when sulphuretted hydrogen abounds, iron pyrites is found in large quantity;* where sulphurous acid, as we have already stated, alum, gypsum, &c., result. The phenomena of the Geysers having been passed in review, Professor Bunsen concludes his memoir by some general considerations, as connected with the relation of the clinkstone, and older trap, and the tuff, and the remarkable occurrence in the latter of numerous hydrated compounds.

We rejoice to know that this and his other papers are only slight sketches, preliminary to the more full and detailed account of his researches, which Professor Bunsen has promised, and for which we look forward with anticipation of most valuable results. There are few fields more perfectly adapted for the study in detail of such phenomena than Iceland, and there are few departments of our science in which less progress has been made than in chemical geology. Professor Bunsen has well remarked, that the attention of geologists has hitherto been almost exclusively directed to the metamorphism of rocks by the action of fire, while the transformations effected by gas and water must have played a scarcely less important part. It may, I think, be fairly doubted, whether masses so little capable of conducting heat, as we know many of the older rocks are, could have been modified to the extent they have, unless we admit the action of water to have been largely concerned in such changes, partly as a conductor of heat, partly as a source of change itself.†

M. Delesse, to whose interesting memoir on the Vosges rocks I have already alluded, has more recently given an equally detailed and careful examination of the Protogene of the Alps‡, and of each of its constituent minerals. He concludes, that protogene is a well characterized granitic rock, of which the principal elements are quartz—two distinct felspars, one the orthose, the other the oligoclase

* For some valuable remarks on the geological bearing of this fact, see the original memoir. Cavendish Society, Vol. I. page 340-341.

† In the quotations from Professor Bunsen's paper, I have used the translation issued by the Cavendish Society in their first volume, 1848.

‡ Annales de Chimie, January, 1849, page 114.

variety; a biaxial mica very rich in iron, and a talc: differing from ordinary granites, having two felspars, by the composition of its mica and by the presence of talc. The analyses of each of these minerals is detailed, as well as that of the several marked varieties of the mass, by which it appears to differ from the mean composition of granite, (of which the author previously published numerous analyses,) only in having a little more oxyde of iron, and magnesia. Among all the numerous varieties of protogene, two distinct classes may be recognized, one possessing a distinctly granitic structure, in which the crystallization is well marked; the other having a schistose structure, in which the crystallization is less distinct, and even confused. These mineralogical differences correspond to a simple difference in chemical composition, the most highly crystallized varieties possessing a larger amount of silica than the others; and the distinctness of the crystallization varying with this variation in the amount of silica. Those varieties in which this element is found in smallest quantity, occur near the boundaries of the formation, as had been previously noticed with regard to granites also.

I would suggest the extreme importance, and indeed the necessity, of a very careful examination of all the circumstances attendant on such phenomena, before attempting to explain this fact of a diminution of silica, as we proceed from the centre of the mass towards its outskirts. So many and successive changes and variations have taken place in such rocks, that it will frequently be exceedingly difficult to render intelligible the causes which have successively produced the result we now see. Towards such an end, however, the contribution of every such truth as those M. Delesse has published, tends most essentially, and it is, in fact, only by such accurate chemical analyses, that we can ever hope to throw light on the phenomena. Among the results announced by M. Delesse, we should not omit to mention, that he finds the ordinary brownish coloured quartz of the protogene (smoke-quartz,) to derive its colour from the presence of organic matter easily volatilized without residue, and which disappears entirely after a slight calcination, the quartz becoming white and transparent, and only losing in weight $\frac{12}{1000}$ Whence was this organic matter derived? If not in these plutonic rocks, where can we hope for a truly âzoic mass? These are questions which immediately rise before the mind, and the facts point to a reaction on the mass of granite rocks, of great interest in considering its origin and mode of formation. But I can only allude to these points.

Passing now, from these applications of chemical investigation to the study of the mineralogical structure of modifications of rocks, to the consideration of simple minerals, we can refer to several valuable additions to our knowledge of the laws which govern their formation, during the past year. The question of Dimorphism has engaged the attention of Pasteur and Nickles. Pasteur has described some crystals of sulphur, artificially obtained from the sulphuret of Carbon, on which both the forms of this mineral, so well known to be dimorphic, were distinctly visible.*

Nickles† has established the dimorphism of zinc. Pure zinc, as stated by Noeggerath, crystallizes in hexagonal prisms. Zinc, antimony, and arsenic were, therefore, the only metals not belonging to the regular system. M. Nickles has, however, found pure zinc, prepared by Jacquelmain's process, to crystallize in pentagonal dodecahedrons, very similar to those of iron pyrites and grey cobalt, thus placing it in the regular system; while it is interesting, at the same time, to find that its dimorphism attaches it to a group of metals, to which, from its chemical properties, it should belong. The fact of tin being dimorphous was known by the researches of Miller and Frankenheim; and G. Rose has shown Palladium and Iridium to be isodimorphous. "We are therefore justified," says M. Nickles, "in anticipating that one day antimony and arsenic will also be found to be dimorphic, and thus subject to the common law, which would appear to place all the metals in the regular system."

M. Pasteur,‡ in a valuable paper "On Dimorphism" in general, gives a list of all known cases of dimorphism, and discusses each very fully. He finds, as the chief peculiarity common to all dimorphic substances, that one of the two forms which they present, is a limiting form, placed, as it were, at the point of separation of the two systems to which the dimorphic crystals belong. Of this many instances are given. From one of the forms you can, by the laws of simple derivation, arrive at the secondary faces which occur on the other form of crystal. From this, then, it follows that dimorphism can be almost predicted. As an instance, M. Pasteur states that prussiate of potass in the ordinary form, very nearly approaches to a right square prism, and that in all probability it will be found

* Annales de Chimie, Dec. 1848, Tom. XXIV. page 459.

† Do. do. Jan. 1848, page 37.

‡ Annales de Chimie, July, 1848, p. 267. Comptes Rendus, March 20th, 1848.

dimorphic, and if so, to be crystallized in this system. The two arrangements, or molecular equilibria, which correspond to the two forms, are equilibria, so closely related one to the other, (although belonging to two different systems, and subject to their general laws,) that they can pass one to the other. Dimorphic substances are, therefore, according to M. Pasteur, isomeric substances, in which the molecular arrangement is slightly different.

The same author has offered some curious remarks on the relation between crystalline form and chemical composition, and the cause of rotatory polarization; and reasoning from the remarkable phenomena presented by the tartrates and paratartrates, states that all polarizing crystals owe this property to the dissymmetry, or want of symmetry, of their molecules.*

In the volume of chemical reports and essays published by the Cavnedish Society, is an admirable resumè of the state of knowledge on isomorphism, and its modifications, which will prove interesting and valuable, as a summary of facts already established, both to the geologist and mineralogist. It is a translation of one of the chapters of Professor Otto's (of Brunswick) Chemistry.

Otto Volger has described some pseudmorphs of Fahlerz.† Damour has given the analysis, and Descloizeau has described the crystalline form of *Malakon*, a hydrosilicate of Zirconium.‡ Descloizeau has restored the name of Christianite§ to the lists of mineralogists, and applied it to a mineral belonging to the harmotome group. It had originally been applied to some crystals from Vesuvius, afterwards proved to be only Anorthite. The mineral now described from Iceland, where it occurs, forming druses in cavities of trap amygdaloid, along with Chabasie and Levyne, at the bay of Dyrefiord, is very similar to, and only a variety of, the lime-harmotome of Marburgh, which has hitherto been considered the same as the Phillipsite of Levy; but M. Descloizeau, after a full discussion of the published analyses, concludes that lime harmotome, and barytes harmotome, are not isomorphic, and that the lime harmotome of Marburgh is not the same species as the Phillipsite of Levy; and proposes, therefore, that the name Phillipsite should be restricted to the

* Comptes Rendus, 22nd May, 1848, page 535.

† Pogg: Annalen, 1848, bd. 5, page 25.

‡ Annales de Chimie, Sept. 1848, pp. 87—94.

§ Annales de Mines, tom. XII. page 5, liv.

minerals from Capo-di-bove, and Christianite applied to the harmotome of Marburgh and of Iceland.

The same author has also concluded, both from crystallographic form and chemical composition, that Gehlenite, (which was considered a variety of Humboldtilite,) is a distinct species.

Mr. Lawrence Smith has announced the discovery of two new species, on pitchblende, near Adrianople—one a double sulphate of lime and uranium, to which he has given the name of Medjidite; and the other, a carbonate of lime and uranium, called by Mr. Smith, Liebigite.*

Mendipite, one of our rarest minerals, has been recognized as occurring at Bilon, near Bonn;† and to the researches of Mr. Townsend we are indebted for a knowledge of the occurrence of several minerals in the County of Donegal, which had not been previously noticed in Ireland, and of which he has presented specimens to our University Museum.

The tendency, however, of more careful research and improved analysis, has been rather to diminish the number of so-called mineral species; and we would refer with pleasure to the recent works of Dufrenoy, Naumann, &c., as exhibiting such results most clearly and satisfactorily. Rammelsberg has also given us another supplement to his most valuable Dictionary of the Chemistry of Mineralogy, in which the work is brought down to the year 1847.‡

We cannot pass from the subject of mineralogy and its important bearings, without referring to the most beautiful and valuable researches of Faraday and Plucker, on the crystalline polarity of Bismuth—researches which, in conjunction with Faraday's previous conclusions on diamagnetism, promise to work a great change in our knowledge of the cosmical forces, which have acted, and are acting, though unseen and unfelt, in producing the present forms of the solid matter around us. M. Delesse has also given some interesting re-

* Comptes Rendus, February 7th, 1848. Silliman's Journal, No. 15, May, 1848. page 336.

The formula of Medjidite is $\dddot{U}\ \dddot{Si} + \dot{Ca}\ \ddot{C} + 15\ \dot{H}$.

„ of Liebigite $\overline{\dddot{U}}\ \ddot{C} + \dot{Ca}\ \ddot{C} + 20\ \dot{H}$.

† Bull. Soc. Geol. France, 9th November, 1847.

‡ Rammelsberg: Handwörter buch des chemische theils des Mineralogie. Third Supplement, 1845—1847.

searches on the polarity of minerals and rocks;* and M. Pasteur, on the relation between crystalline form, chemical composition, and rotatory polarization in minerals,†

There is one other matter of very great interest, as bearing on the application of chemical discoveries, to the explanation of geological phenomena, to which I must refer in a few words. The influence of time in modifying or inducing chemical affinity, had already engaged the attention of several chemists. In considering this subject, our fellow-member, Mr. Sullivan, was led to imagine that the time in which a given chemical effect could be produced, might be influenced by a mechanical vibration of the bodies acted on; that is, by the communicating to the particles of the body motions, such as would allow them readily to assume a new arrangement. And on testing this idea, it was found to be fully borne out by experiment. The substances operated on were principally those whose atoms are held together very loosely, and which were very readily acted upon by heat, electricity, light, &c. In most of the cases tried, the changes observed were chemical; but in some, the changes were such as could only be discovered by an alteration of physical properties, especially by the action of polarized light. In fact, very slight mechanical action appears to alter the structure, as it were, of fluids as well as of solids. The only one of these experiments—the results of which have as yet been published—was the conversion of styrole into metastyrole. Hoffman and Blyth found that by heating the fluid to which they had given the name of styrole, to a temperature of 200°, cent. in a closed tube, it was converted into a vitreous mass, which they called metastyrole. Now Mr. Sullivan has found that the same effect was produced, by vibrating a tube full of it for thirty hours. The vibration was given by clock-work, which set a bow in motion.

Other experiments have since been tried, some of which, by the kindness of Mr. Sullivan, I can state. A mixture of protoxide of nickel, and chloride of lime, was partially converted into peroxide of nickel, and chloride of calcium. This frequently requires several weeks. Again: aldehyde is converted into metaldehyde.

A solution of oxalic acid mixed with a solution of chloride of gold, perchloride of platinum, or chloride of iridium, and ammonia, is de-

* Comptes Rendus, page 548, November, 1848.

† Ann. de Chimie, page 442, December, 1848.

composed with the evolution of carbonic acid. Boiling does not effect the same result, although the continued action of sun light does, (not, however, in Ireland.)

If the body obtained by the action of chlorine on light muriatic ether, and which has the formula of $C_4\ H_2\ Cl_2$, and which is not acted on by an alcholic solution of potash, be vibrated for several days, it will then be decomposed, by such a solution, into muriatic acid and some new compounds. In fact, it will be converted into the body of the same formula in the isomeric group, and which is obtained by the action of chlorine on olefiant gas, and which yields up its chlorine to potash. This is a peculiarly interesting experiment, and goes far to support the views of Laurent and Gerhardt, as to the substitution of hydrogen by chlorine.

Again: if oil of turpentine be kept for some time in contact with oil of vitriol, it will lose its power of causing a ray of light to turn to the left; but if vibrated for a considerable time, it will gradually resume its original power.

Although only just commenced, I think that the few cases I have stated will be more than sufficient to show that these ingenious experiments of Mr. Sullivan have opened up a new field of enquiry, which promise to yield a rich harvest of results, bearing most importantly on questions of chemical affinity, and, as will be evident, having a direct and immediate influence on the progress of mineralogical knowledge. Mr. Sullivan is extending these experiments, and I doubt not, that before the close of the year, he will have obtained new results of equal or greater interest than those I have been enabled to give.

Such, gentlemen, is a very brief summary of what has been made known during the past year in the several branches of our all-embracing subject. Limited, as our view necessarily has been, to such a short period of time—a period also in which less activity has been displayed in scientific pursuits than is wont, from the absorbing nature of the many political changes which have occurred—such a sketch became almost unavoidably a mere statement of facts, and not as we should prefer, were it possible, an elimination of principles. Still even such a dry detail of apparently isolated facts, becomes extremely useful, when we seek to advance the boundaries of our knowledge, or promote the steady progress of our science. If, therefore, the past year may not have added much to our acquaintance

with the higher and more general laws of our science, it *has* done much to facilitate that laborious accumulation of facts, or in other words, that knowledge of phenomena, on which, to be useful, any such advance must be based.

Indeed on reviewing the progress of knowledge, especially as regards the sciences of observation for some years, we might be almost tempted to declare, that its great feature was a tendency to minuteness of detail, rather than to largeness of view—a desire to sift with all possible accuracy the peculiarity of each individual case that presented itself, rather than to obtain from such observations a knowledge of the principles essential to the production of the phenomena, and therefore generally applicable under analogous, though not identical, conditions—to seek rather to become acquainted with the verbiage in which the ideas were clothed, than with the ideas themselves. Unquestionably before we can even attempt to comprehend those ideas, we must understand the language in which they are conveyed; but this knowledge once obtained, to continue its pursuit, is but to acquire a succession of words unsuggestive of any new combinations of thought, and unproductive of any useful result. No really useful, at least no extendedly useful, application of any scientific principle has ever been made, excepting after a patient and careful investigation of the laws by which it was regulated; and after some degree, at least, of completeness in the knowledge of those laws has been attained. In seeking, therefore, for any useful applications of our science, we seek not for instances of mere present or momentary utility, in which the knowledge acquired by the geologist may have been successfully applied to the immediate acquisition of increased produce, or wealth, or the promotion of the comforts, or the supply of the wants of society. The efforts of thought have a higher value than all this; and the additional energy which such researches give to the workings of intellect, forms as true and as sound a claim on our admiration and encouragement, as any means which they afford of applying the truths thus acquired to human uses.

But while we are perfectly satisfied that the lower consideration of how such studies may tend to increase man's wealth, never will, never can, lead to that patient, and cautious, and laborious preparation which must be undergone before any sound knowledge of the principles involved be attained, we are equally convinced, that once

attained, *it is the duty, it ought to be the pleasure,* of every one to whom any of this knowledge is given, to contribute in every way to diffuse the information thus acquired, and to point out, as far as in his power, every increased facility, and every additional means, which his science can suggest, to promote the happiness and the comfort of others.

In this point of view, some communications during the past year on the practical applications of geological principles, are not without their interest, even to a scientific society.

The valuė of geological knowledge in mining operations is now so generally admitted, that we need scarcely allude to the many important ways in which the scientific principles of the one throw light upon the other. Acknowledging this fact, M. Amedée Burat, already known as the author of an useful work on geology applied to mining,* has discussed the question of the continuity of metalliferous deposits in depth. This question is one of general interest, and perhaps even of special interest in this country, where the opinion very commonly prevails, that our metallic lodes diminish essentially in productiveness, as the depth from the surfaee increases. To determine, therefore, whether, *a priori,* such should be expected, though purely a geological question, is yet one having an essential practical bearing on the resources of this country. M. Burat, pointing out the principal localities in which new sources of metallic ores (excepting iron) have been found since 1815, and taking the return of the produce from these new sources, as compared with the whole produce, shows that the increase of production has taken place principally in the countries of mines already wrought, either by the extension of the existing works, or by re-opening mines previously abandoned. Now a considerable extension has taken place of these works *in depth,* and M. Burat proceeds to discuss the application of theoretical principles to such cases, seeking to prove the unsoundness of the prevailing notion of the decrease in productiveness, with the increase in depth, of metallic lodes. The cases cited by M. Burat, are valuable facts controverting this notion, but he appears to me to have overlooked some of the most essential conditions of his problem. It is a perfectly established fact admitted by all, that the nature of the rocks which form the walls or boundaries of a metallic vein,

* "Geologigie applique."

exercises a most important influence on the productiveness of the lode; so well acknowledged is this indeed, that the working miner can in most cases predict, with tolerable accuracy in any district with which he may be acquainted, the chances of a portion of the vein being productive or not from the nature of the rock adjoining, or what he calls the *country*. An instance well known of this may be cited from the Derbyshire lead veins, where the productiveness of the veins is at once reduced to almost nothing, when they pass through the *toadstone* of that country, (a rock which, in fact, derives its name from this circumstance, the word being a corruption of *todt stein*, dead or unproductive stone,) while the vein again becomes productive, as soon as it has passed beyond this influence. Another instance on the large scale might be given from Cardiganshire, where all the lodes are confined to a district in which the rocks have a peculiar lithological character, although belonging to the same series as those which cover a very large area beyond, but in which no lodes have been traced. Now, this fact M. Burat has altogether overlooked, although it appears to me perfectly essential for the correct solution of the question. In Derbyshire, for instance, the ore-bearing strata are well known, and below them no miner would think of sinking into the old red sandstone in search of lead; the vein may be there, nay, may even increase in width and importance, but the valuable contents of it will be absent. We may, therefore, fully grant to M. Burat, that the vein or fissures (subsequently filled in,) being the result of subterranean action are continuous in depth, without in the least granting that the metalliferous contents of that vein are equally continuous. The presence or absence of these ores being dependent on other conditions, the indefinite proposition that metalliferous deposits are continuous in depth, will not hold.

Besides the variations in the productions of a lode to which I have alluded, as dependent on changes in the mineral character of the enclosing rock, there are other variations even where the "*country*" remains the same, dependent on other causes with which we are not as yet fully acquainted. Thus, independently altogether of those "nips" or "squeezes" which every miner is familiar with, the section of any large mine will at once show that the productive portions of the lode form detached masses, which, viewed as to the position of their occurrence in the direction or length of the vein, observe in each mine a certain amount of regularity in their distri-

bution—that is, the extent or size of the productive portion as compared with the extent of the unproductive, observe in the main, a given ratio. Now, in the case we have supposed, viz.—when the enclosing rock continues the same in depth, and in length, I think we are justified in asserting that the same law of distribution of the productive portions of the lode will hold in depth, as is proved to hold in length; and that therefore in any given vertical sinking, we ought to anticipate certain alternations of richer and poorer portions of the lode. If this be the case, it is obvious that the occurrence of one of these poorer zones ought not by any means to discourage the further exploration of a mine, other circumstances being favourable.

We would, therefore, restrict the general proposition that "metalliferous deposits are continuous in depth," within certain limits; but if thus restricted, and expressed perhaps in this way, "that metallic lodes will continue to hold the average amount of ore at all depths, where the containing rock or 'country' continues the same," we believe that it may most unhesitatingly be admitted, and acted upon.

But the productiveness of a lode in ore, and its productiveness in profit derivable from the working of this ore, are two very distinct questions; and while from the principles I have laid down, it will be evident that to determine the probability of the former, is purely and essentially a question for a geologist, the latter must be decided on totally different and independent grounds. Here the situation of the mine, the command of economical power, the facility of drainage, transport of ores, &c., &c., and in no small degree, the skill and intelligence of the managers, all exercise a most important influence.*

I have dwelt on this subject as one which is of practical interest in Ireland, and for the determination of the general elements of which the progress of an accurate survey, such as that now being steadily carried on, will furnish all the necessary data.

To M. Riviere we are indebted for a sketch of the metalliferous deposits, especially of Blende and Galena, which occur in that

* A very striking instance of how the profitable working of a lode is dependent on totally different circumstances, from the productiveness of the lode in ore, may be cited in the case of the great quantities of *pure metallic copper*, found near Lake Superior; but the expense of the removal of which, as it had to be all cut with cold chisels, was so great, that this *pure metal* could not be brought into the market at the same price, as the metallic copper smelted from the poor ores of this country.

portion of the right bank of the Rhine, between Coblentz and Dusseldorf. The principal rock of the district is greywacke, more or less schistose: a few patches of tertiary rocks occur, and some igneous intrusions, principally of diorite. Some of the veins are of unusual size: there are two principal systems—1st, composed of quartz, blende, galena, &c., and traces of copper—the 2nd, of quartz, copper pyrites, grey copper (panabase,) and other minerals of copper. Of the 1st system, all the lodes have a general relation, and are nearly parallel, having a mean direction from E.N.E. to W.S.W. Their general direction corresponds with that of the rocks, and probably depends on the system of dislocations which have disturbed the district. The date of the lodes is well marked as posterior to that of the slate, but anterior to the formation of the anthracitiferous beds above, as these contain rolled and rounded masses of them; these blocks being more and more decomposed, and less in size, as they are further removed from their source.* M. Benoist has described the metallic deposits of the recently acquired French dominion of Algiers; the principal of which already being worked are of iron and copper, but lead, antimony, and zinc, also occur; the general direction corresponds with that of the Atlas mountains, and is about east and west, &c.

A very valuable contribution to the mining history of these countries, has been published in the second part of the second volume of the Memoirs of the Geological Survey. Mr. Hunt has here brought together many old and interesting notices of the history of the lead mine districts of Cardiganshire, and Mr. Smyth, mining geologist to the geological survey, has given a full and detailed description of the lodes, mode of working, dressing ore, &c., &c. In the same volume are tables of the amount of copper ores for the years 1845-46-47, produced from Cornish mines, with the amount of copper produced, and the value in money—tables of the amount of ores from foreign mines, and from British and Irish mines, sold at Swansea, from the year 1804 to 1847.

An inspection of the portion of those tables relating to Irish mines suggests some curious thoughts. Of the forty sources from which copper has been derived during the period mentioned above (forty-three years), not a single mine has continued to produce during the

* Comptes Rendus, January, 1848 page 138.

entire period—five have sent ore to market for only one year; twenty-four for no more than five years; eight for ten years; while only five have furnished a supply for twenty years or upwards. Similarly with regard to English and Welsh mines, with very few exceptions, excluding of course, Cornwall. From Cornish mines alone, in the year 1847, 155,985 tons of ore were produced, amounting in money value to £889,927; while *from all other sources*, including 35,700 tons from foreign mines, there were only 50,819 tons of ore sold at Swansea.

We cannot think that this uncertainty in the produce of Irish mines is due *altogether* to an absence of the ore, although frequently it has been so; we *know* it is not due to a want of skill, or technical education, in the working agents in general; but we believe it arises in many cases from ignorance of the true sources of success in mining operation, on the part of *the individuals or companies who undertake these speculations.* There have been also legal impediments now partly removed, and which exerted a seriously injurious effect on such undertakings.

In the same volume, for the first time, and with considerable difficulty, has been given a return of the lead ore raised, and lead smelted in the British Isles for 1845-46, and '47, compiled, as are also the tables of copper, by Mr. R. Hunt, keeper of Mining Records.

The application of geology to agriculture has also attracted considerable attention during the past year. The discovery of the value of some deposits of phosphate of lime, in the cretaceous series, has led to the careful statement by geologists of the position and extent of such deposits, and the probable amount derivable from them, both in this country and in England. M. Durocher has entertained the question of the relation existing between the mineral nature of the soil and its vegetable productions,* with special reference to Brittany. The rocks of that district, without any regard to the age of the geological formations, may be divided into five distinct groups—1st, granites and granitoid schists—2nd, clay slates and greywackes—3rd, quartzose grits and slates—4th, tertiary beds, argillo-gravelly and flinty—5th, calcareous. On the other hand, considered merely agriculturally, there are three great divisions: 1st, tillage

* Comptes Rendus, 13th November, 1848, page 506.

and pasture lands; 2nd, forests; 3rd, heaths and wastes. M. Durocher points out how in Brittany and adjoining districts, the forests are almost exclusively confined to two kinds of formations, the tertiary argillaceo-flinty beds, and still more the quartzite and quartzose schists. These last rocks, although not covering any great extent, contain more of the forests than all the other rocks taken together. The author divides the peninsula of Brittany into four distinct zones; the littoral, on the north and south, chiefly on granite and crystalloid schists; the central, of clayey schists and greywacke, with some tertiary deposits; and the intermediate zones of quartzose rocks, mixed with schists and some granite masses. The coasts are more fertile and more inhabited; next to them the central zone, where pasture lands abound, and which produce most butter: then the intermediate zone in which the forests occur. The prevalence of wood and heath, on the tertiary beds, is stated to be due to the constancy of their clayey character; the kinds of tillage also, and the species of wild plants vary with the formation, the principal variation being due to the clayey or sandy nature of the soil, the presence or absence of calcareous matter, (whether artificially introduced, or naturally present,) and the vicinity of the sea. On the schistose and tertiary deposits of a clayey nature, most of the pasturage, and beautiful grass lands occur; but they are less profitable for the feeding of horned cattle, than the pasturages which are on the argillo-calcareous beds, where the forage grows rapidly.

Buck-wheat (sarrasin) is invariably cultivated on granitic siliceous and argillaceous soils: much less so, and wheat is produced with profit, where they can assist the soil by calcareous additions, lime, marl, or shelly sand, as along the coast, or in the immedite vicinity of calcareous beds; while the culture of sarrasin entirely disappears in Normandy where the secondary limestone occurs; the whole culture is there different—the oak and chesnut give place to the elm. The elm, the maple, and the walnut love the calcareous soils—the oak, the chesnut, the beech, and aspen, love the siliceous and argillo-siliceous. The author points out many other peculiarities, and states, that as far as his observation goes, there is a greater number of characteristic plants on the oolitic and tertiary limestone districts, than on the palæozoic limestone, the latter being less friable. The influence of the presence of lime on the abundance of terrestrial and fresh-water shells, and crustacea, is also pointed out, as being most marked.

In connexion with this subject, I may briefly allude to a communication by myself, during the past year, to this Society, in which I traced on the map of the County of Wicklow, the extent of area covered by the great drift deposits; the variation in their mineral character, from gravels to stiff tenacious clays, and the very important influence which their presence or absence exerted on the productiveness of the land. So long since as the year 1844, in a paper which I laid before you, "On some of the more recent deposits in Ireland," and an abstract of which is published in your Journal, speaking of these deposits, I used the following words:—"And here I would remark, that the richness and fertility of this magnificent amphitheatre," (that including the Dargle, Enniskerry, Kilruddery, &c.) "so contrary to what might naturally be expected from soils derived from an eminently siliceous district, are almost entirely due to the presence of this thick covering of calcareous clays and gravel." And, again, speaking of the districts further south, of Wicklow Head, it was stated, that these same clays and gravels "exercise such a powerful influence on the agricultural produce of the soil, that the outline of these deposits forms a tolerably accurate index to the value of the land." Their importance in affecting the productiveness of the district in other ways, was also pointed out.* That this view was correct, the more detailed examination of the same district in connexion with the Geological Survey, has fully borne out; and on transferring to an index map of the county, the townland boundaries, and obtaining from the General Valuation, conducted under Mr. Griffith, the average money-value per acre for each townland; and representing these money-values by any conventional colours, similar to maps recently exhibited by Sir Robert Kane, to the Royal Irish Acadamy, the interesting and somewhat curious result has come out, that occasionally for miles together, the line, which, on the map representing differences of money-value by colours, corresponds to the line of division of the colours, is identical with the line which, on our geological map, represents the boundary of these drift deposits; the colour indicating the higher money value being *invariably* that which occurs on the portion covered by the drift. Now, although we believe that any conclusions as to the *distribution of soils* of varied money-value, derived from an examin-

* Journal Geol. Soc. Dublin, Vol. III. page 65, &c.

ation of such townland valuations, must be almost useless, excepting *in the broadest and most general way*, owing to the exceedingly artificial and varied nature of these townland divisions; still even an approximate result of this kind offers a strong confirmation of the views I so long ago announced, of the important influence which the geological structure of this district exercises on its agriculture; and a strong confirmation also of the great value of having such a general valuation as that conducted for Ireland, intrusted to the able superintendence of one as intimately acquainted with the geology of the country as Mr. Griffith is. I may also allude to the circumstance that now, for the first time, the extent of these deposits has been shown on our geological maps.

M. Boubeè also has laid before the Geological Society of France a report on a small farm, in which he traces very clearly the immediate and evident connexion which exists between the geological structure and the fertility of the soils. He shows, that on this farm, there are three very distinct kinds of soil. 1st, argillaceo-sandy and ferruginous, (most unproductive)—2nd, clayey, (less sterile)—3rd, argillaceo-calcareous, (fertile.) He points out the cause of the several characters, how completely it depends on the general proportions of the ingredients in the soil, and how *(cæteris paribus,)* this also produces the physical difference as to wetness, tenacity, coldness, &c.; and tracing the geological structure of the country, he shows the immediate cause of these varieties, and points out the economical means of improving them. M. Boubeè very justly expresses his perfect conviction, that the principles of agricultural geology will one day become the true basis of the increased fertility of the land; and that as, without the knowledge of the principles of geology, the pursuit of mines frequently becomes ruinous, so without this knowledge the pursuit of agriculture must equally remain incomplete, and comparatively unproductive.

I am inclined to attach considerable importance to such communications as those to which I have referred, because I believe them to be instances of progress made in the proper direction, and calculated to elucidate the true grounds or rules on which any attempt to benefit the progress of agriculture in a country should be made, so far as *the public* are concerned. To arrive at a knowledge of, or to indicate the actual money value of, the soils of a district, appears to be utterly futile, as this depends on so many changing circumstances,

such as position, increased or diminished facilities of communication, demand for certain kinds of produce, mode of cultivation, &c., so that what might be a fair estimate of the money value of any given soil, derived from an examination of that soil, during any given year or time, might be a perfectly fallacious estimate for any other year or period; but the intrinsic value, as it has been called, or as, at the valuable suggestion of my friend, Professor Handcock, I would call it, the *natural powers* of a soil, these may be, with comparative facility, ascertained, and these ought to be, and must be, the true groundwork on which to base any efforts at improvement. The consideration of these natural powers of the soil enters also as a most essential and necessary element, in all questions as to size of agricultural holdings, relative advantages of various modes of cultivation, or different means of improvement; and in fact into all the questions now exciting interest, as bearing on agricultural improvement. Now, I think, we have clearly seen, even from the limited cases brought before us, during the past year, that these, viz—*the natural powers of any soil—depend essentially on the source from which that soil has been derived; and therefore, on the geological structure of the district;* and as a necessary consequence, that however this latter may have been overlooked, or totally neglected in the discussion of such questions as I have alluded to, such omission is fatal to the proper or complete solution of the question. And further, we may remark, that vast and immediate as has been the benefit conferred on agriculture by chemistry, still the materials on which the chemist operates—the rocks and soils of our country—are essentially geological, and the results carefully ascertained in one instance, can only be safely or readily applied to any other, by a knowledge of the character of these materials, and of the source from which they have been derived. It was from a consideration of this kind, that the system in operation for the collection of soils and subsoils, through the districts under examination by the officers of the Geological Survey in Ireland, was devised by Sir Henry De La Beche, and myself, and is now carried on under my direction; the sanction of the Chief Commissioner of her Majesty's Woods, &c., having been obtained for the necessary expenditure. These soils, &c. are finally handed over to Sir Robert Kane, and I am confident that the results of his careful analyses will prove valuable.

Another direction in which some additions to our knowledge of the

useful applications of geology has been made, has been in the careful examination of the waters derived from known geological sources, and then tracing the effect of the matter held in solution in such cases. Of this, the most prominent instance, during the past year, has been the detailed analyses of the several waters used in those districts where Goitre prevails, by Mr. Grange.* These waters were derived from the talcose, anthracitic, and cretaceous rocks of the valley of Isere. They were all procured on the same day in July, so that the results might be fairly compared. The geological formations of the district are well known, presenting considerable mineralogical and chemical differences, and the mountains are sufficiently high to allow of the examination of waters, taken at different elevations, from the level of perpetual snow, to a few hundred feet above the level of the sea. We shall not enter into any detail, but simply state the results, which were these: that the quantity of dissolved salts increases from the summit of the mountain towards the plain; that, in the talcose and anthracitic formations, the sulphates of soda, lime, magnesia, and potass, diminish relatively to the total quantity of dissolved salts; that in the anthracitic formations, the sulphates of soda, lime and magnesia, are in greater absolute quantities than in the talcose formations, forming from eighteen to thirty-seven per cent.—these formations being rich in pyrites, gypsum, and dolomites; and that in the cretaceous formations, carbonate of lime and magnesia increase considerably. The author details the differences, and points out the importance of such enquiries; and observing in all the waters used in the villages, where cretinism is endemic, a proportion of magnesia, varying from ten to fifteen per cent., he was led to attribute to this salt, the prevalence of this terrible endemic. This view is confirmed by the presence of magnesiferous rocks in all other places where goitre prevails in Europe, and in the Andes also, where the same disease occurs. The author then points out the simple remedy which might be used to counteract this evil, by separating the magnesia, &c.

M. Deville has also given the results of several analyses of drinkable waters, procured from rivers, springs, and wells. The remarkable point of his results is, that he has established the presence of a

* Annales de Chimie. December, 1848, page 364. Comptes Rendus, October, 1848, page 358. Edin. Phil. Jour. January, 1849, page 181.

small amount of silica in all these waters, which had previously been overlooked; from an analysis of six specimens of river waters from different sources, he finds it forms nearly one-seventh of the matter in solution—a somewhat less proportion in spring and well waters; and he considers that this small dose of silica is of great importance in all drinkable waters, and together with the azotized matter, plays an important part in fertilizing land, &c.

The importance of such results, although bearing primarily on the districts from which the waters examined were procured, is by no means limited to them, and they show *how desirable would be a careful examination of the source from which the water was to be procured, as well as of the water itself,* before any definite step should be taken for the supply of this, or any other city, with water for the use of the inhabitants.

The intimate connexion which exists between the varying features of any district, and its geological structure, must necessarily strike any observer; and thus the geologist necesssarily becomes, to a certain extent, a physical geographer. The discussion, also, on the grand scale, of the causes which have produced or modified our mountain chains, the form of our continents, the position of our land, and the extent of its encompassing oceans, all have engaged the deep attention of geologists. There has, however, we think, been a growing tendency to such studies, forming a marked feature in the direction which the pursuits of geologists have recently taken; and such must inevitably be the case, in proportion as the intimate and necessary dependence, which exists between the great cosmical forces becomes daily more and more established.

To Mrs. Somerville we are indebted for a brief and clearly expressed compilation of useful facts on physical geography, from which, no doubt, future editions will remove many of the minor errors, almost necessarily incidental to a work compiled by those who have not themselves examined the questions they discuss. The Cosmos of Humboldt has been completed, exhibiting to the end the same eloquent descriptions, the same abundance of facts, and the same widely extended research, which characterized its commencement. And we have also had numerous illustrations of the physical characters of local districts. But on the progress of such enquiries, the Physical Atlas of Mr. Johnston, completed during the past year,

is calculated to exert an influence infinitely greater than all these works together. Founded on the similar work of Berghaus, but almost as superior to it as it was to the total absence of such maps, this great work has been executed with a skill in the execution, with a research in the details, and with an ability in the mode of grouping them, which reflect the highest credit on those who projected as well as those who carried the design into execution. I shall not detain you with even the briefest allusion to the many important facts laid before the student of natural history or of meteorology in these maps; but simply allude to that portion which more especially concerns the geologist. Here he will find grouped together on one map, the many hundred observations which have been found scattered through books, often difficult of access, often unintelligible to the ordinary reader; but which are here graphically laid before his eye, in these beautiful maps of the mountain chains. Another sheet gives him the valuable chart of the geology of the world, compiled by M. Boué, whose acquaintance with the literature of our science is perhaps unrivalled, and corrected by its author up to the most recent date. And not to dwell on any other feature, we have a palæontological map of the British Isles, drawn up by Professor E. Forbes, and accompanied by very full and carefully prepared tables of fossils, with most interesting descriptions of their geological distribution. This map—the first yet published in which the formations of England and Ireland are correctly synchronized—together with its accompanying letter-press, appears to me the most valuable contribution which has been made to the British geological student for many years.

It is difficult for those who have not themselves engaged in such a work, to estimate the amount of patient, careful, and detailed investigation, which such a publication embodies, the many thousands of observations which are there brought together, and exposed to the eye by some little line; and it is therefore difficult fully to appreciate the value of such a work, as a means of conveying facts, or what is of still greater importance, as a means of arriving at a knowledge of the laws which govern them. When we consider that we cannot take one single step in advance, until we have ascertained and reached the line which marks the boundary between the known and the unknown in the domain of science, and that the measure of that advance must be estimated by the position of the point from which we started, the influence of such condensed and digested exhibitions of the *known*, in

encouraging, directing, and influencing the future progress of science, becomes obvious. To this valuable work of Mr. Johnston we look for supplementary additions, as knowledge increases; and should the hopes of Humboldt be realized, and that 1850 should mark the completion of a magnetic map of the world, such an addition would doubtless be at once suggestive of many unthought of points of connexion between physical geography and geology.

There is also another work, which to me appears by far too important in the influence it is calculated to exert on the future progress of natural knowledge in these countries, to be passed over. We have for many years past been indebted to the officers connected with both the military and naval service of this country, for many useful records of facts, and several valuable contributions to science; and more recently, the results springing from the many voyages of discovery, and surveying expeditions, sent out by the British government, have been both varied and important. Still, considering the number of officers engaged on foreign stations, frequently under circumstances extremely favourable for making observations of great importance, the amount of scientific contributions derived from such sources, was certainly not commensurate with the number of persons engaged. It would be idle to enter into the many determining causes of this; but unquestionably one of these, and a principal one, was the non-possession of some manual pointing out to them the points necessary to be noticed, the methods of observations, the bearing of enquiries, one on the other, and the interest attaching to the result. It was therefore with unmixed pleasure, that we have seen the announcement of a "Manual of scientific enquiry," prepared expressly for the use of the navy, under the sanction of the Lords of the Admiralty. I had hoped that the appearance of this volume would have enabled me to enter more fully on its contents; but the fact that it has been intrusted to the general charge of Sir John Herschel, the choice of subjects, and the names of those selected to treat of them, are sufficient guarantee, that the volume will be such as must materially affect the progress of enquiry; and which, although the honour of projecting it be due to the Board of Admiralty, must equally reflect its influence on the military and on the civil service. Such a step forwards, and in the right direction, must inevitably be followed by a steady advance.

The very imperfect sketch I have been able to give you of the

various communications which have promoted the advance of geology, during the past year, prepared, as it has necessarily been, while fully occupied with other matters, will yet, I trust, be sufficient to prove, that we have not at least retrograded; and that steadily and irresistibly the great tidal wave of knowledge has rolled on. The most distant and inhospitable shores have yielded up their contributions; the nearest and most accessible have been more closely searched. New facts have been accumulated, new phenomena observed, new laws ascertained, the action of new forces investigated; the connexion of our pursuits with the other physical sciences more closely pointed out, and the oneness of action of the great cosmical forces, as to time and place, more clearly demonstrated. Our progress has been certain and definite; our still further advance can never be impeded, while we remember the many useful warnings which the history of every science presents, of the danger of attempting the explanation of phenomena by ill-matured hypotheses, instead of removing the difficulty by exact and cautious observation.

If, gentlemen, I shall in anything have contributed to such sound advance, I shall, *so far at least*, have endeavoured to show myself grateful for the high honour you have done me in placing me in this chair.

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March 14th, 1849.—"On the changes of the Earth's figure and climate, resulting from forces acting at its surface;" by HENRY HENNESSY, ESQ.

The author commenced by observing—That in the present state of Geology, no geological theory which professes to explain phenomena of a general character can be admissible, the results of which do not harmonise with the knowledge we possess of the earth's figure. It becomes important, therefore, to examine how far such a harmony of results exists with respect to certain theories which in recent times have received much attention from geologists.

"Two different general hypotheses, connected with different geological theories, have been proposed in order to account for the observed figure of the earth:

"1. That the earth was in a fluid state anterior to its present state.

"2. That it was always chiefly in a solid state, but that the action of superficial causes might tend to give it a spheroidal figure.

"The first hypothesis, combined with known mechanical and physical laws, serves to account for all the observed phenomena of the earth's figure, and of the variation of gravity over its surface. On the second hypothesis, the latter class of phenomena are inexplicable without the use of additional arbitrary assumptions. The chief phenomenon relative to the earth's figure, for which it is proposed to account by the aid of the second hypothesis, cannot be explained unless it be proved that the effects of centrifugal force, in modifying the position of masses at the earth's surface, predominate over all

other modifying actions. If the predominance of centrifugal force in influencing the direction of the transport of matter at the earth's surface be granted, it will follow, in general, that the mean diameter of the earth at the equator must increase, while that at the poles must diminish. If the earth's figure were not originally spheroidal it would thus tend finally to assume such a form. Let it be supposed to have any irregular shape whatever—let a continuous surface be conceived described around the centre of gravity of this irregular body, such that if the mass of the entire were included within it, the phenomena of its rotation would be unchanged. The axis of stable rotation of this mass, must be that of the greatest or least of its moments of inertia; but as the density of the interior of the mass must be supposed to increase towards the centre, the greatest of the moments of inertia cannot differ much in value from the least, for otherwise the assumption would be made of a greater mean equatorial than polar diameter. It follows, therefore, that the effective surface of rotation of the mass must be nearly spherical, or entirely so, as Sir John Herschel has supposed,* and consequently that of any considerable mass of fluid covering it. If now this mass be set in rotation about its axis, the centrifugal force thus produced would tend to give the fluid a spheroidal surface. The fluid would therefore accumulate about the equator, and recede from the poles. If the surface of the solid mass should, from any cause, become spheroidal, or if its mean equatorial radius should become greater than its mean polar radius, the difference between the oblateness of the surface of the solid and that of the fluid masses would decrease, as I have elsewhere proved.† It follows, that if the earth's figure became continually more spheroidal, the waters would tend to accumulate about the polar regions, and to recede from the equatorial regions. The extent of polar dry land would thus tend towards diminution, while that of the equatorial regions would, on the contrary, tend towards increase.

This conclusion is further confirmed by the following considerations: From what is known respecting the volume of the waters at present covering our planet, it is certain, that if the earth were originally a sphere rotating on its axis, the fluid would accumulate about the equatorial regions, forming an equatorial ocean, while at each pole a

* Astronomy: Chap. iii. page 120.

† Proceedings of the Royal Irish Academy, Vol. iv. page 337.

great continent would exist, having a considerable mean elevation above the level of the sea.*

If the currents tending to transport matter towards the equator predominated in mechanical effect over those tending to transport matter towards the poles, it would follow, that the area of these continents would be continually lessening, and the entire mass would, at the same time, and from the same causes, have a tendency to assume its present oblate figure. If by the action of any forces, land should exist, even to a small extent, in the equatorial regions, it must necessarily follow, that from the cause above assigned, the ratio of its area to that of the circumpolar land, would continually increase. The rising of the level of the equatorial sea, by the deposition of the transported matter of the circumpolar land, cannot affect the truth of this conclusion, because such a rise in the sea level, would everywhere tend, in almost exactly the same proportion, to lessen the area of the dry land.

It may, therefore, be generally concluded, *that at any epoch of the earth's existence, the ratio of the area of dry land at the equatorial regions, compared to its area at the polar regions, should be greater than at any preceding epoch.*

The theory of the earth's figure just considered does not admit of a former state of fusion of the earth, arising from intense heat, and consequently not of any slow progressive change of climate at its surface, resulting from the refrigeration of its mass. Geological observations, especially those which refer to the former existence of organised beings, prove that such a gradual change of climate has taken place; or that, during the remoter periods of the earth's existence, the mean temperature at its surface was higher than at more recent periods. To account for this change of climate, without appealing to a former state of fusion of the globe, Sir C. Lyell has proposed a theory which has deservedly attracted the attention of all philosophical geologists. If, in accordance with the fundamental assumptions of this theory, it be granted, that changes in the relative areas of the dry land and water in the polar and equatorial regions, were the effective causes of the gradual change of climate at the earth's surface, deduced from geological observations, it must follow, that so far as observations reach, the tendency of the

* Proceedings of the Royal Irish Academy, Vol. iv. page 339.

forces modifying the form of the earth's surface was to increase the mean polar diameter, and to decrease the mean equatorial diameter. The hypothesis of the earth's primitive solidity cannot, therefore, serve simultaneously to account for its present figure and for the gradual change of climate at its surface. The hypothesis of a state of fluidity of the earth anterior to its present state, presents no such inconsistency among its results; and, consequently, we are entitled to reject, in its favour, the hypothesis of the earth's primitive solidity.

April 11th, 1849.—"On some Australian Ores;" by JAMES APJOHN, M.D., Professor of Mineralogy to the University of Dublin, &c. &c.

Dr. Apjohn detailed the results of his examination of some copper ores from South Australia, specimens of which had been presented to the University Museum, by the Rev. Dr. Todd.

"Notice of a new chemical examination of Killinite;" by JOHN WILLIAM MALLET, ESQ.

The substance known to mineralogists under the name of Killinite, was discovered in 1817 by the late Dr. Taylor, who read a paper on the subject before the Royal Irish Academy, on the 23rd June of that year, containing a description of the mineral, with its analysis by Dr. Barker, Professor of Chemistry to the University. It has been since analyzed by Captain Lehunt, and Mr. Blythe, pupils of Dr. Thompson. The results of these three analyses were as follow:—

	Dr. Barker.	Capt. Lehunt.	Mr. Blythe.
Silica, ...	58.49	49.08	47.925
Alumina, ...	24.50	30.60	31.041
Protoxide Iron, ...	2.49	2.27	2.328
Lime, ...	"	.68	.724
Potash, ...	5.00	6.72	6.063
Protoxide Manganese, ...	"	"	1.255
Magnesia with Manganese,		1.08	.459
Magnesia, Lime, and Iron,	.50	"	
Water, ...	5.00	10.00	10.00
	95.98	100.43	99.795

Having in my possession some pure specimens of the mineral, I thought it worth while, during a course of analytical instruction under Dr. Apjohn, to make another examination of the mineral, the account of which is the subject of the present short notice. This mineral derives its name from the first and only locality in which it has been found, namely, Killiney near Dublin, where it exists imbedded in coarse granite, and accompanied by crystals of feldspar, garnets, spodumene, and black tourmalin. The specimen on which the following experiments were made, was found in the cutting recently made by the Wicklow, Wexford, and Waterford Railway Company, on the south eastern side of Killiney Hill.

The physical characters of the mineral, as exemplified in this specimen, are as follow. It occurs in small masses, having a foliated structure, and in irregular crystals. It gives by cleavage a rhombic prism, whose angles are about 135° and 45°, as determined by the common goniometer. The fracture is uneven. The colour varies from a light to a dark olive-green, with a shade of brown. The crystals are frequently found covered with a brownish-yellow coating of peroxide of iron, probably owing to decomposition of the mineral. The streak is white, with a slight tinge of yellow. The lustre is vitreous, but dull.

The mineral is slightly translucent on the edges, but opaque in mass. It is sectile. Its hardness is nearly, but not quite equal to that of crystallized Fluor Spar.

The specific gravity, as determined by three experiments on different carefully selected specimens, was found to be as follows:—

No. 1, ...	2.6603	Mean,...... 2.6561
No. 2, ...	2.6526	
No. 3, ...	2.6553	

This mineral does not attract the magnetic needle. When rubbed on woollen cloth it becomes positively electric. The intensity of its electricity, however, is low. It does not phosphoresce by the application of either friction or heat. The nitric and muriatic acids act on it but slightly, chiefly extracting the oxide of iron which it contains. Sulphuric acid, however, decomposes it, setting silex free.

Before the blowpipe it presented the following phenomena:— Heated in either an open or closed glass tube, it turns black, and gives off a sublimate of water. Alone on charcoal, or in the platina forceps, it turns white, intumesces, and fuses with some little diffi-

culty into a snow-white porous enamel: with carbonate of soda on charcoal, it easily fuses into a brownish-green semitransparent bead, which, with a larger quantity of soda, becomes opaque. With microcosmic salt on the platina wire, it gives a transparent colourless glass. Added in great excess, it gives in the oxidating flame a glass which is transparent, and of a light yellow colour when hot, but which becomes nearly opaque, and assumes a smoke-grey colour when cold. With borax it behaves in the same manner. On the platina wire, with a mixture of bisulphate of potash and fluor spar, it gives the purplish-red flame characteristic of lithia, slightly but distinctly.

Chemical Analysis.

To obtain information as to the chemical constitution of the mineral, the following analysis was made in the Laboratory of the College of Surgeons, under the superintendance and direction of Dr. Apjohn. The method adopted for the estimation of its earthy constituents was as follows: 28.89 grains of a pure specimen were pulverized and strongly ignited, for the purpose of determining the water. This same portion was then fused with about three times its weight of a mixture of carbonate of soda and potash. The fused mass had a light bluish-green colour and radiated structure, very much resembling some species of Wavellite. It was then dissolved in muriatic acid; the solution evaporated to perfect dryness, water digested on the residue, and the silica filtered out. From the filtered solution the iron and alumina were precipitated by ammonia, and these afterwards separated by caustic potash. Oxalate Ammonia was then added to the remaining solution, which precipitated the lime, thus completing the first part of the analysis, there being no perceptible traces of manganese or magnesia. By these means the following results were obtained:—

	28.89 grs. contain		per cent
Silica, ...	15.28	Silica, ...	52.89
Alumina, ...	9.60	Alumina	33.24
Protoxide Iron,	.95	Protoxide Iron,	3.27
Lime, ...	.42	Lime, ...	1.45
Water, ...	1.06	Water, ...	3.67

For the purpose of determining the alkalies, recourse was had to the decomposing agency of hydro-fluoric acid; the vapour of which was made to act upon fifty grains of the mineral moistened with pure water, in the manner pointed out by Brunner.

By this method it was completely disintegrated, the silex being dissipated in the vaporous state, and the other constituents of the mineral couverted into fluorides. Sulphuric acid was then poured on, and the whole evaporated to dryness. Being re-dissolved in water, ammonia and carbonate of ammonia were added to it, which precipitated every thing but the alkalies. The solution was then filtered, evaporated to dryness, and ignited to expel the ammoniacal salts. The alkaline sulphates were weighed, redissolved in water, and converted into chlorides, by the addition of chloride of barium. The solution being again evaporated to dryness, they were weighed as chlorides, which having been dissolved in water, the potash was precipitated by chloride of platinum. The residual solution was then freed from the excess of chloride of platinum, by sal-ammoniac, filtered, evaporated to dryness, and ignited, when it left a small portion of chloride of lithium, which was weighed as such, there being no soda present. By this analysis the alkalies were found to be—

In 50 grs.	Potash,....	2.47	=per cent.	Potash,....	4.94
	Lithia,....	.23		Lithia,....	.46

Hence we find the constituents of the mineral in one hundred grains to be as follow:—

Silica, ...	52.89	1.135
Alumina, ...	33.24	.647
Protoxide Iron, ...	3.27	.91
Lime	1.45	.005
Potash, ...	4.94	.105
Lithia, ...	.46	.030
Water, ...	3.67	.408
	99.92	
Loss	.08	

Dividing each of these numbers in the first column, by the atomic weight of the body whose quantity it represents, we obtain the numbers given in the second column above, showing the equivalent proportion in which those bodies exist in the mineral.

Or throwing the lime, potash, lithia, and protoxide of iron into one, we have—

		Relative Proportions.
Silica, ...	1.135	5
Alumina,.............	.647	3
Protoxides,...........	.231	1
Water, ...	.408	2

Dividing each of these by the lowest number, their relative proportions are very nearly as above, which leads to the formula—

$$M\,O, 2\,Si\,O_3 + 3\,(Al_2\,O_3\,Si\,O_3) + 2\,H\,O$$

representing the protoxides by M O.

This formula differs so materially from that of Spodumene, $\left(2\,(Al_2\,O_3, Si\,O_3) + 2\,Li\,O, Si\,O_3\right)$ which is the only mineral liable to be confounded with Killinite, as, I think, to entitle the latter to be considered as a *distinct* mineral species, most nearly allied, however, to Spodumene, and ranking in a chemical arrangement under the alumino-alkaline silicates. The analysis appeared to be worthy of a brief record, as preceding analyses continued the question in doubt of Killinite being classed in mineralogical treatises as a distinct mineral. It likewise possesses some interest in another point of view, as demonstrating the presence in this mineral of the rare alkali, lithia, which has hitherto been found in but small quantity, and sparingly distributed in nature.

May 9th, 1849.—"On the Geology of the County of Carlow;" by PROFESSOR OLDHAM, President of the Society.

This communication was principally a description of the geological map of the County of Carlow, published by the Geological Survey of Ireland. Granite covers all the eastern portion of the county, forming fully two thirds of its entire area. It is of the same general character mineralogically, as the granite of the great axis of Wicklow, and has exerted a precisely similar reaction on the slates which rest upon it. These latter are well seen, covering a very large portion of the Mount Leinster range, (hitherto unnoticed) forming the top of the hill of Tomduff, and in numerous small and detached patches caught up in the granite, on the mountains of Blackstairs, and in the country about Borris and Graignenamanagh. The slates at Tomduff will afford excellent examples of the changes which have resulted from the action of the granite upon them. They abound in Andalusite, Schorl, Staurotide, &c.

A very small portion of the old red sandstone occurs close to Gore's Bridge, being the last portion of the great extent of this rock which occurs in the adjoining County of Kilkenny.

Resting upon the granite at a very low angle, occurs the carboniferous limestone which forms the valley of the Barrow, and is itself capped by the coal measures of the Queen's County and Kilkenny, and which extend for a short distance into the County of Carlow. The subdivisions of the carboniferous limestone into lower, calp and upper, were pointed out, and the reasons for this classification given. The calp only forms a narrow band, of no great thickness. The period of the granitic eruption is clearly seen to be prior to the deposition of the lowest portions of the carboniferous limestone, which is undisturbed by it, and into which no veins of the granite pass.

Covering a very large area of the county, are thick deposits of limestone, gravel, and clay, which, however, diminish very much towards the south; passing into the County of Wexford by the valley of the Slaney, at Newtownbarry, and into Kilkenny by the valley of the Barrow, at Graiguenamanagh and St. Mullins.

The paper was illustrated by the map, and by sections, on a large scale, of various parts of the district.

"The variation of Gravity at the Earth's Surface, on the hypothesis of its primitive solidity; by HENRY HENNESSY, ESQ.

The use of the pendulum as an instrument of geological investigation is twofold.

1. In determining the general laws of the earth's structure.

2. In finding, from observed local irregularities in its oscillations, the position of masses of matter of abnormal density, compared to the mean density of the earth's crust. The first application is evidently the most important for furnishing the fundamental data of geological theory. Any comprehensive theory of geological phenomena necessarily involves the consideration of the earth's general structure; and consequently, in order to be admissible, its deductions should not be opposed to the indications of all extensive series of pendulum experiments. In this paper I propose to examine how far the theory founded on the hypothesis of the earth's primitive solidity, would serve to account for the results deduced from such experiments.

In order to examine the laws of the variation of gravity at the earth's surface, on the hypothesis of its primitive solidity, some sup-

position should be made relative to its interior constitution. It is not allowable to assume, that the arrangement of the interior strata of the earth was originally such as to cause the variation of gravity at its surface, to be that which would satisfy observation.

This would be equivalent to assuming that the strata of the sphere possessed peculiar spheroidal figures; and it may be fairly asked, why should not these figures require explanation as well as the present figure of the earth's outward stratum? If, as remarked by Mr. Hopkins,* the matter primitively composing the earth were of uniform density under uniform pressure, it would follow that the interior strata would be all concentric and spherical.

In this form, as being the only one really admissible, I have already considered the hypothesis referred to, in my paper on the influence of the earth's figure on the distribution of land and water at its surface.† The analytical expressions obtained in that paper will assist in promoting the object of this.

Adopting the notation of the paper referred to, and remembering that $U_i = O$, $Vi = o$, when i is not 2, equation (a) becomes

$$C = \frac{4\pi}{3r}\Big[a^3 + a_1^3\,(D_1 - 1) + a_2^3\,(D - D_1)\Big] + \frac{4\pi a^5}{5r^3}\Big[\alpha Y_2 + (\alpha_1 D_1 - 1)U_2\Big]$$
$$+ \tfrac{1}{2}\,gr^2 \sin^2\theta.$$

If G represent the intensity of gravity at any point on the surface, having the latitude $90^\circ - \theta$, the above equation will give, after being differentiated, and then divided by $-\,dr$,

$$G = \frac{4\pi a^3}{3r^2}\Big[1 + \frac{a_1^3}{a^3}(D_1 - 1) + \frac{a_2^3}{a^3}(D - D_1)\Big] + \frac{12\pi a^5}{5r^4}$$
$$\Big[\alpha Y_2 + \alpha_1 (D_1 - 1)U_2\Big] - g\,r \sin^2\theta.$$

$$\text{But } \alpha\, Y_2 = -\,\frac{5\,q\,D + 6\,(D_1 - 1)e_1}{2\,(5D - 3)}\,(\cos^2\theta - \tfrac{1}{3}),$$
$$\alpha_1\, U_2 = -\,e_1\,(\cos^2\theta - \tfrac{1}{3}),\quad r = a\,(1 + \alpha\, Y_2),$$

hence, on developing r, and neglecting small quantities of the second order, we shall have

$$G = \frac{4\pi a D}{3}\Big\{Q + \Big[\frac{5\,(4D - 3)\,q - 6\,(D_1 - 1)\,e_1}{2\,(5D - 3)}\Big]\cos^2\theta\Big\},$$

Q being constant, and nearly equal to unity.

* Report of the British Association for 1847, page 43.
† Proceedings of the Royal Irish Academy, Vol. iv. page 333.

Let G_1 represent gravity at the equator, then

$$G = G_1 \left\{ 1 + \left[\frac{5\,(4\,D - 3)\,q - 6\,(D_1 - 1)\,e_1}{2\,(5D - 3)} \right] \cos^2\theta \right\}$$

Using the values of D and D_1 given in my former paper, the cos efficient of $\cos^2\theta$ becomes $\frac{95\,q - 10.5\,e_1}{49}$. By observation this co-efficient is $\frac{5q}{3} - \acute{e}$; $\acute{e}$ being a fraction obtained by combining the results of pendulum experiments, and being greater than the measured oblateness of the earth. The difference between these coefficients is $\frac{7(13\acute{e} - 3e_1) - 55q}{98}$; and hence, in order that it may disappear we should have $e_1 = \frac{98\,\acute{e} - 55}{21}$. But the greatest value of e is $\frac{5}{7}\,q$, hence it is also the greatest value of $\acute{e}$. The observed value of $\acute{e}$ is $\frac{1}{288}$*; the greatest value which it can have, in accordance with the theory founded on the hypothesis of the earth's primitive solidity is $\frac{1}{404.6}$; consequently that theory must be considered as wholly incapable of explaining the observed variation of gravity at the earth's surface.

Recapitulating the results of this and my former papers, which refer to the theory founded on the hypothesis of the primitive solidity of the earth, it may be concluded, that the hypothesis alluded to, entirely fails in affording explanation of the following phenomena:—

1. The secular refrigeration of the earth's surface.
2. The observed ellipticity of the earth.
3. The variation of gravity at the earth's surface, as determined by pendulum experiments.

It is scarcely necessary to add, that the values of the coefficients of precession and nutation, resulting from the constitution of the earth, which has been considered, would deviate widely from their values as observed. Such a result has been already obtained by the distinguished author of the report referred to.†

All these phenomena are completely explicable on the hypothesis

* Humboldt: Kosmos, Bd. I. S. 174.

† At page 44 of the Report.

of a fluid state of the whole earth anterior to its present state, and a profound examination of the physical consequences of this last hypothesis, shows that when these consequences are thoroughly considered, seeming discrepancies disappear, and a wonderful harmony is found to exist between theory and observation.

June 13th, 1849.—"On the Geology of the County Kildare;" by PROFESSOR Oldham, President of the Society, Director of the Geological Survey of Ireland.

The author described in detail the geological structure of the County of Kildare, illustrating his remarks by the geological map published by the Geological Survey of Ireland, and by sections. The detail of these investigations will be published in connexion with the Geological Survey.

November 14th, 1849.—"Notice of the former existence of small glaciers in the County of Kerry;" by John Ball, Esq., M.R.I.A., &c.

When visiting the peninsula of Brandon, in Kerry, about three years ago, I was struck with the appearances exhibited at several points on the northern side of the range of mountains which extend from Tralee to Brandon Head, and which appeared to me to be attributable to the operation of extinct glaciers; but owing to circumstances, I was not at that time enabled to examine the phenomena with sufficient care, to justify me in expressing a decided opinion on the subject.

Having subsequently observed in many parts of the Counties of Cork and Kerry, traces of mechanical agency upon the surface of rocks, which evidently were not due to the action of glaciers, but rather to that of floating ice, borne by marine currents against, or along the shores of a glacial sea, I was the more desirous to examine with care those points which had appeared to me to present evidence of the former existence and operation of true glaciers.

During a short visit to Kerry, in October, 1848, I had an opportunity of revisiting a portion of the same district, and of confirming the impression which I had previously received. I proceed briefly to notice some of the facts which seem to me to furnish conclusive evidence of the former existence of glaciers in the south-west of Ireland.

The most accessible, and at the same time the least doubtful site of an extinct glacier which I observed, is traversed by the road which descends from the summit of Connor Hill, towards Tralee Bay. After winding along the face of the steep cliffs of Connor Hill, the road passes at a short distance below a wild rocky hollow in the mountain, which contains a small lake or tarn, called on the ordnance map, Lough Doon. The streamlet which descends from this hollow forms, at a considerable distance below the road, a second small lake, called on the maps, Lough Beirne. A small glacier appears to have filled up the hollow now occupied by Lough Doon, and to have descended nearly to the level of Lough Beirne. The first indication which strikes the observer who ascends from the road to the upper lake, is the regular and uniform manner in which the

rocks at the north-western side of the lake are rounded and smoothed. This appearance is not confined to the flat ledges which lie immediately between the lake and the slope of the mountain, but extends to the steep rocks which form the amphitheatre, reaching to the height of eighty or ninety feet (judging from recollection) above the level of the lake. I observed some traces of furrowings on the surface of these rocks, similar to those which are the common results of the passage of glaciers in the Alps; but as they were not very distinct, and as their origin might possibly be attributed to other causes, I should not have considered the evidence sufficiently conclusive, were it not for the distinct and well characterised moraine, which extends from a little below the upper lake nearly to the level of Lough Beirne. The position of this moraine, which is altogether inexplicable by any hypothesis as to the effects of currents of water, seems to me to leave no room for doubt, to any observer accustomed to the appearance of those bodies. Although its dimensions are masked by the growth of a turf bog upon either side, it forms a distinct and almost continuous ridge, easily traceable by the eye, and which is found on walking along it, to be chiefly composed of large angular blocks, precisely as is seen along the banks of recent glaciers. It is worthy of remark, that this moraine is by no means regularly parallel to the bed of the streamlet, by which the drainage of the upper lake is now conducted.

Although it does not appear necessary to detail the appearances which I observed at other points in the same range, especially as continual stormy weather was very unfavourable to complete or satisfactory examination, I may state that I noticed indications of several other small glaciers, of a similar character to that above described. But the glen which lies immediately beneath the steep northern side of Brandon mountain, and which contains a succession of lakes, the lowest and largest of which is called Lough Cruttia, seems undoubtedly to have been occupied by a glacier of more considerable dimensions. There are, however, some indications which would show that this glacier may have, at different periods, found an exit in different directions; at one time discharging its ice-stream through the gorge below Lough Cruttia, and at others finding an additional vent across the lower part of the ridge, which forms the northern boundary of the lake. Those who may visit the spot in less unfavour-

able weather than I encountered, will be rewarded by a view of some of the wildest and most striking scenery to be found in Britain.

Though but very imperfectly acquainted with the Killarney mountains, I may be allowed to direct attention to the former existence of a small glacier on the north-eastern side of Purple mountain. In ascending from O'Sullivan's road, a little above the woods which clothe the lower slopes of the mountains, the stream is seen to cut through a moraine, which makes a semicircular sweep towards the left, presenting its convex side to the lower part of the mountain. Although the rapid growth of turf bog has completely covered the centre of that side of the mountain, the permeable nature of the moraine has resisted its encroachments, and it offers to the pedestrian the only path wherein his foot does not sink in the spongy masses of *sphagnum*, which so speedily invests every other portion of the surface.

I shall conclude, by suggesting the following inferences from the facts which have fallen within my very limited observation.

1st. Whatever may have been the climatal condition of this country during any previous period, at the time when these small glaciers existed in Kerry, the mean temperature cannot have been excessively low, nor such as would have admitted of any considerable extension of glaciers throughout the adjoining districts. Taking the case which I have described, as a fair example of the other instances of the occurrence of glaciers in the same district, we find that the present height of Lough Doon above the level of the sea is 1117 feet; even admitting that, (as is very probable,) the sea level at the period in question was from 100 to 200 feet higher than at the present time, we still have the fact of the existence of a natural reservoir for snow, at no less than 900 feet above the sea level, surrounded by rocks, which rise above it to the height of more than 900 feet; yet the glacier stream which was fed by the annual overflow of this reservoir, did not—if my observation be correct—descend to a lower bed than that of Lough Beirne, which at the period in question must have been about 500 feet above the sea level. These facts would indicate the existence of a climate but little, if at all, colder than that which now exists in the north-eastern part of Ireland. It is scarcely necessary to observe, that this condition would not have been followed by a colder period, as with the increase of the glaciers,

the moraines must have been carried to a greater distance, and could not have been left suspended on the slope of a mountain, as in the case mentioned on the Purple mountain.

2ndly. The conditions which caused the existence of these small glaciers, must have continued with tolerable uniformity for a considerable time. Although a temperature which must have frequently fluctuated about the freezing point of water, would have caused a far greater amount of disintegration than the very trifling effects now produced on these hard rocks, by the action of the elements; yet considering the very slow rate of annual motion which is attained by small glaciers of slight depth, the moderate extent of rocky surface from which the moraines must have been supplied, and the small proportions which would have been deposited on the lateral moraine, it seems necessary to allow a long period, including several centuries at least, for the continuance of that portion of the glacial epoch, to which the existence of these small glaciers should be referred.

The pressure of other pursuits has made me so ill informed as to the progress of geological investigation in Ireland, that I cannot say how far these trifling observations may have been anticipated by others of a more accurate character. They have been drawn up with a desire rather to direct attention to the subject, than to support any peculiar opinion or theory.

December 12th, 1849.—"On the geology of Howth;" by PROFESSOR OLDHAM, President of the Society.

IN this communication, resulting from the examination of the district by the officers of the Geological Survey, the author detailed the structure and relations of the slaty and sandy beds of which the mass of the hill of Howth is composed, pointing out their extent and mineral character, and the remarkable disturbances and contortion to which they have been subjected. The peculiar arrangement of the so-called quartz-rock was also shown. Numerous dykes and veins of trap rocks penetrate the slates, as near the Baily Light House, the needles, &c., some of them interesting for the extent and distance to which they ramify in the slates. The carboniferous series occurs, resting immediately on these cambrian slates; the lower

beds, seen at Balscaddan Bay, are thin, earthy, and of dark colour, highly fossiliferous. Upon these are seen solid light grey limestones, with the ordinary fossils of the lower limestone of Ireland. These beds are locally very magnesian, of a light dove-brown colour, and full of cavities, which cavities are generally coated with crystals of pearl spar.

Over all, spreads the great deposit of the drift clays, and limestone gravels, occurring in isolated and detached patches along the eastern shore; but forming the surface of all the flatter and less elevated portion of the promontory to the north-west. Some interesting proofs of the amount of degradation which has taken place since the formation of the deposit, are afforded by the occurrence of detached portions of it, forming the summits of what are now islets along the shore, but which must have been, at the period of the deposit of these clays, united with the main land.

January 9th, 1850.—"Analysis of a specimen of mica, from the Co. of Wicklow;" by William K. Sullivan, Esq.

Although there is probably no mineral of which we possess so many excellent analyses as of mica, yet its true constitution is very far from being definitively settled. Recent analyses show, that the substitution of bases may take place to a very great extent; and that its optical and other physical properties are not in such intimate relation with its chemical constitution as was at first supposed: or rather, that our knowledge of that relation is very imperfect. The analysis which I am about to bring under your notice, shows this in a very remarkable manner; and at the same time proves, that even the commonest of Irish minerals affords a wide field for investigation. The specimen examined was obtained by Professor Oldham, during the progress of the Geological Survey of Ireland, and transmitted by him to the Museum of Irish Industry for analysis, under the belief, from the circumstances under which it occurred, that its constitution must be remarkable.

It was devoid of colour, and transparent; but when heated strongly, it became dull, as was also the case when boiled for some time with very strong hydrochloric acid; the edges of the very thin

scales appearing to have been partially decomposed in the latter case. Its specific gravity was not determined. It was biaxial. It was my intention to have made a second analysis, but want of material rendered it impossible to do so; some of the constituents were, however, determined a second time, with the portion employed for the determination of the Fluorine. In 100.000 parts it contained—

			Oxygen.
Silica,	47.411		24.639
Alumina,	36.213	16.951	17.884
Peroxide of Iron,	3.110	0.933	
Protoxide of Manganese,	0.030	0.006	2.188
Lime,	0.014	0.003	
Magnesia,	1.539	0.597	
Potash,	5.510	0.935	
Soda,	2.506	0.647	
Calcium,	0.913		
Fluorine,	0.861		
Water,	2.371		
And traces of Glucina, oxide of Chromium, Boracic and Phosphoric acids.			
	101.008		

The quantity of boracic acid was also determined, and amounted in one case to 0.070; but as yet I do not place much reliance on any of the determinations which I have made of that substance; indeed it is unnecessary for me to mention the great difficulties attending the determination of substances occurring in such exceedingly small quantities, since their determination, when present in large quantities, is still to some extent a desideratum in chemistry. I do not give the determinations of chrome and glucina, for the same reasons; but as I have taken up the subject of the examination of a great number of other interesting specimens of Irish mica, in which these substances occur., I hope to be able to supply this deficiency in a short time.

The mode of analysis did not differ much from that usually pursued, except in the attempt to determine the Fluoric, Boracic and Phosphoric acids. The process followed for this purpose was founded upon the fact noticed by Von Kobell, that carbonate of baryta does not precipitate boracic acid from solutions containing iron; but on the other hand precipitated the entire of the fluoric acid. The mineral was fused with three times its weight of a mixture of carbonate of

potash and soda, the fused mass treated with water, filtered: the solution boiled with a little pure carbonate of ammonia, in order to separate alumina and silica, filtered; chloride of iron added to the solution, then carbonate of baryta, and the whole allowed to digest until the iron was completely separated. The whole of the fluoric acid was then precipitated, as also the phosphoric acid, but not the boracic acid. The solution from which the fluoric acid was separated, was evaporated to dryness, the dry mass treated with sulphuric acid, and then with alcohol, the alcoholic liquor saturated with ammonia evaporated to dryness, ignited and weighed. The iron precipitate was well washed, treated with dilute hydrochloric acid, without heat, and carefully precipitated with perfectly pure caustic ammonia. The precipitate was dried, ignited, and weighed. The weighed mass was then treated with concentrated sulphuric acid in a platinum crucible, covered with a piece of glass, to serve as a test of the hydrofluoric acid, evaporated to dryness, ignited, the ignited mass dissolved in water, to which a little acid was added, the iron carefully precipitated with ammonia, collected on a filter, dried, ignited, and weighed; the difference of weight was calculated as fluorine. The residue of iron was then dissolved in hydrochloric acid, and the first precipitate. (by carbonate of ammonia) of silica, and alumina added to it, the mass evaporated to dryness, heated some degrees above 212°, moistened when cold, with hydrochloric acid, boiled with water, and filtered to separate the silica. The filtered solution was then treated in the manner recommended by Fresenius, for the determination of phosphoric acid.

The oxides of chrome, alumina, and glucina, were separated in the following manner, which is simply an application of the usual methods, employed for the determination of these bodies. The acid solution of the fused mineral, after the separation of silica, was treated with perfectly pure ammonia in excess, the precipitate consisting of the oxides of iron, chromium, and a trace of manganese, alumina, and glucina was collected on a filter, well washed, dried and fused with twice its weight of a mixture of carbonate and nitrate of potash in equal proportions; the fused mass treated with water, which dissolved the chromate of potash, and a small portion of the others, which were precipitated by the addition of a little ammonia. The liquor filtered from the latter precipitate, was evaporated to

dryness, treated with sulphuric acid and alcohol, and then with water, filtered, and the oxide of chromium well washed, ignited, and weighed. The portion left undissolved after the treatment of the fused mass with water, together with the precipitate thrown down from the aqueous solution by ammonia, were then dissolved in hydrochloric acid, precipitated with ammonia, well washed, and digested with caustic potash, filtered; and the iron left undissolved, determined in the usual manner. The solution in potash was neutralized with hydrochloric acid, reprecipitated with carbonate of ammonia, well washed, and a current of sulphurous acid gas passed through it, suspended in water, until the whole was dissolved. The liquid was then boiled for some minutes, until the whole of the alumina was precipitated as sulphite, which was collected on a filter, dried, ignited, and weighed. The glucina was then precipitated with ammonia.

The relation of the oxygen in the bases, with the formula, R O, R_2 O_3 respectively, and in the acid, is very nearly as—

$$1 : 8 : 11$$

which corresponds with the formula 3 R O, Si O_3 + 8 R_2 O_3, Si O_3 or in full:—

$$3 \left.\begin{matrix} M_n \\ C_a \\ M_g \\ K \\ N_a \end{matrix}\right\} O, \ Si\ O_3 + 8 \begin{matrix} Al_2 \\ Fe_2 \\ Cr_2 \end{matrix} \left\{ O_3 \left\{ \begin{matrix} Si\ O_3 \\ B\ O_3\ ? \end{matrix} \right\} \right.$$

which is exactly the formula for the Fuchsite of Schaffhäutl. In the latter, however, more than three per cent. of the alumina is replaced by oxide of chrome; the mineral is also of a green colour, while the quantity of this ingredient, present in the Irish specimen, is not sufficient to tinge it, and the quantity of peroxide of iron is nearly double that in the Fuchsite. I have, however, since obtained several specimens from other localities, in which the amount is found to vary, between a slight trace, and several per cent, and the depth of colour accordingly, but the analyses of which are not yet completed. The amount of potash substituted by soda and magnesia, is also much greater in the Irish specimen than in the Fuchsite. In the former lime is also present, apparently in greater quantity, than

would be sufficient to neutralize the fluorine, which is not the case with the latter.

It is impossible to say in what condition the fluorine exists in mica, unless we consider that a portion of the oxygen is substituted by it. If, according to this view, we suppose an atom of fluosilicide of calcium to replace an atom of silicate of lime, we would get exactly the same formula as above. If the relation of the oxygen was 1 : 9 : 12, as Rammelsberg remarks, the formula would be much more simple, namely :—

$$R\,O,\ Si\,O_3 + 3\ Al_2\,O_3\ Si\,O_3$$

which would give exactly the general formula of L. Gmelin, if we assumed with him that silicic acid should be $Si\,O_2$ and not $Si\,O_3$, namely :—

$$\left(K\,O,\ 3\ Si\,O_2\right) + 3\left(Al_2\,O_3\ Si\,O_2\right)$$

These considerations lead to the supposition, that this mica, as well as the fuchsite, has undergone very considerable metamorphic action, or that both form an intermediate stage of the transition of slate into true mica.

The presence of soda has been observed in other micas besides the fuchsite; as for instance, in a specimen from Jefferson Co. New York, analysed by Meitzendorff, which contained 0.66, but a trace of lithia was also detected. Not the slightest indication of the presence of the latter could be observed in the Wicklow specimens. The large amount of soda in the latter is easily accounted for by the fact, that nearly all the felspar of the Wicklow granite is albite.

The boracic acid most probably replaces $Si\,O_3$, as I have represented in the formula; but I am utterly at a loss to account for the condition of the phosphoric acid, unless it be merely accidental. I have not attempted to introduce the water into the formula; but this question, as well as many other interesting ones, I hope to be able to treat in a fuller manner, in a more complete examination of the Irish micas, with which I am at present occupied.

AT THE

ANNUAL GENERAL MEETING

HELD ON

WEDNESDAY, FEBRUARY 20th, 1850,

THOMAS OLDHAM, ESQ. PRESIDENT, IN THE CHAIR,

The following Report from the Council was read :—

THE Council have to offer to you their report for the past year.

During this period, ten new members were added to the Society, viz. :—A Maguire Giles, Esq.; F. J. Sidney, Esq. L L.D.; Rev. J. Galbraith, F.T.C.D.; Professor Melville, Queen's College, Galway; Thomas Maguire, Esq.; William Dawson, Esq.; Emerson Dawson, Esq.; Rev. A. B. Rowan; Rev. W. A. Willock, F.T.C.D.; and J. G. Medlicott, Esq., an Associate Member.

After due consideration, it was resolved that the under-graduates of the University should be admitted as Associate Members of the Society, on being proposed and seconded in the usual manner as ordinary members, and on payment of the nominal fee of 5s. per annum.

The Council having deemed it expedient that life compositions paid by members should be formed into a reserved fund, £55. stock was purchased, this being the sum paid for life subscriptions since 1845. This stock is invested in the names of Thomas Oldham, Robert Ball, and William Edington, as Trustees for the Society.

A dutiful address was agreed to by the Society, and presented to her gracious Majesty, on her visit to this part of her dominions— an address was also presented to Prince Albert. These addresses were graciously received.

Many members having fallen into arrear, and others having ceased to subscribe, a circular was addressed, acquainting the for-

mer that if their subscriptions were not paid, their names would be removed from the roll of the Society, and offering to restore the latter to the roll, on payment of £1. in lieu of their arrears, and £1. for the current year. This circular brought in a number of arrears, and several old members accepted the conditions, and rejoined the Society, while those from whom it was found impossible to obtain subscriptions have been struck off. The present effective strength of the Society is thirty-three life members, and seventy-seven annual.

Your Council considering that it would promote the objects of the Society, have offered prizes under the following conditions:

"That three prizes be offered by the Society, each of the value of Five Pounds in books, to be awarded for the three most valuable papers in the order of merit, that shall be communicated and read to the Society prior to the 31st of December, 1850, on Theoretical or Descriptive Geology, or the application thereto of any of the kindred sciences.

"Competition to be free to all persons, except to members of the Council of the Society.

"The Society not binding itself to the publication of any papers presented for such competition, nor to award any prize unless papers of adequate merit be presented."

The Treasurer's account exhibits a receipt of £104. 3s. 1d. during the year, out of which, as above stated, £55. has been invested. It will be observed that upwards of £60. has been expended in printing; and it is satisfactory to know that the Journal of the Society is much sought for by kindred institutions.

Abstract of Treasurer's Accounts for the year ending January 1st, 1850.

Dr.	£.	s.	d.	Cr.	£.	s.	d.
To Balance in favour of Society on last year's Account.	62	8	5½	By purchase of £55. 3¼ per cent .Stock at £91⅝,	50	13	2
— Life Subscription,	10	0	0	— Gratuity to Servant,	1	10	0
— Admission Fees,	3	0	0	— Printing, Stationery, Books, &c. from *November*, 1848,	69	10	7
— Annual Subscriptions,	76	5	0	— Porter's Wages,	12	0	0
— Interest on £55., 3¼ per cent. Stock, for half year ending 10th October, 1849,	0	17	11	— Assistant Secretary, one year,	20	0	0
— Received for articles of Furniture,	0	14	0	— Sundry incidental expenses,	6	8	6
— Balance due to Treasurer,	13	6	1½	— Collector's Poundage,	6	0	3
	£166	11	6		£166	11	6

(Signed)

WM. EDINGTON, Treasurer.

We have examined the above account, and compared vouchers, and find that there is a balance due to the Treasurer of £13. 6s. 1½d.

Dublin, 20th March, 1850.

(Signed)

ROBERT CALDWELL,
R. BALL.

DONATIONS

RECEIVED SINCE LAST ANNIVERSARY.

TO THE LIBRARY.

1849.

May 9.—Rules and List of Members of the Athenæum Club, 1847 presented by the Club.

June 6.—Reports of the proceedings of the Geological and Polytechnic Society of the West-Riding of Yorkshire, 1848, presented by the Society.

June 6.—Quarterly Journal of the Geological Society of London, No. 18, presented by the Society.

June 6.—Geological Map of the County of Carlow, published by the Geological Survey.

July 21.—Memoirs of the Geological Survey of the United Kingdom. Figures and Descriptions illustrative of British Organic Remains, decade 1, presented by the Chief Commissioner of Woods and Forests.

July 21.—Sheets 57, 58, and 59 (S. E.) of the Geological Survey of Great Britain, presented by the Chief Commissioner of Woods and Forests.

Aug. 8.—Memoirs of the Geological Survey of the United Kingdom. Figures and Descriptions illustrative of British Organic Remains, decade 2, presented by the Chief Commissioner of Woods and Forests.

Sept. 12.—Quarterly Journal of the Geological Society of London, No. 19, presented by the Society.

Oct. 31.—Fauna Antiqua Sivalensis. Nine parts of plates, and one of letter-press, presented by her Majesty's Government, through Sir Henry T. De la Beche, C. B.

Nov. 14.—Meteorologische Beobachtungen Angestellt auf Veranstaltung der naturforschenden Gesellschaft, in Zurich, 1837—1846, presented by the Zurich Society.

Nov. 14.—Meteorologische Beobachtungen angestellt von der naturforschenden Geasellschaft in Zurich Januar bis Dezember 1848, presented by the Zurich Society.

Nov. 14.—Die wichtigsten Momente, aus der Geschichte der Naturforschenden Gesellschaft in Zürich von ihrer Gründung au bis zur. Feier ihres hundertjährigen Jubiläum's, presented by the Zurich Society.

Nov. 14.—Bibliographische Notizen über die Zürcherischen Naturforscher, Geographen, Aerzte und Mathematiker, &c., presented by the Zurich Society.

Nov. 14.—Mittheilungen der Naturforschenden Gesellschaft in Zürich, Heft 1 and 2, presented by the Zurich Society.

Nov. 14.—Proceedings of the Literary and Philosophical Society of Liverpool, during the 37th session, presented by the Society.

Nov. 21.—Quarterly Journal of the Geological Society of London, No. 20, presented by the Society.

Nov. 28.—Report of the British Association for the advancement of Science, for 1848, presented by the Association.

TO THE MUSEUM.

1849.

April 18.—Specimen of Anthracite or Stone Coal from Gwendraeth, Wales, presented by William Edington, Esq.

April 18.—Two specimens of Australian Copper Ore, presented by William Edington, Esq.

April 18.—Specimen of Copper Ore from Cuba, presented by William Edington, Esq.

Resolved.—That the Reports now read be confirmed, and such parts of them, together with the Treasurer's accounts, as the Council may think fit, be printed and circulated among the Members.

A ballot then took place, when the following gentlemen were elected Officers of the Society for the ensuing year :—

President:

LT. COL. PORTLOCK, R.E.

Vice-Presidents:

SIR H. DE LA BECHE, C.B.
JAMES APJOHN, ESQ. M.D.
REV. H. LLOYD, D.D., S.F.T.C.D.
RT. HON. THE LORD CHANCELLOR.
ROBERT BALL, ESQ., L.L.D.
RICHARD GRIFFITH, ESQ. L.L.D.

Treasurers:

WILLIAM EDINGTON, ESQ.
S. DOWNING, ESQ.

Secretaries:

ROBERT MALLET, ESQ.
PROFESSOR OLDHAM.

Council:

C. W. HAMILTON, ESQ.
JOHN MACDONNELL, ESQ. M.D.
THOMAS HUTTON, ESQ.
ROBERT CALLWELL, ESQ.
PROFESSOR ALLMAN,
F. W. BURTON, ESQ.
REV. S. HAUGHTON, F.T.C.D.
PROFESSOR HARVEY,
JOHN KELLY, ESQ.
PROFESSOR HARRISON, M.D.
CHARLES P. CROKER, ESQ. M.D
WILLIAM DAWSON, ESQ .
REV. J. GALBRAITH, F.T.C.D.
F. J. SIDNEY, ESQ. L.L.D.
JOSEPH WELLAND, ESQ.

The President then read the ANNUAL ADDRESS. After the Address had been concluded, the following Resolutions were unanimously passed:—

"That the cordial thanks of the Society be presented to the President, for his exertions in the cause of the Society during the past year, and for the excellent addrss now read, with a request that he allow it to be printed."

"That the warmest thanks of the Society be presented to the several Officers of the Society, for their zealous attention and endeavours to promote the objects of the Society during the past year.

The Society then adjourned.

ADDRESS.

GENTLEMEN,

AT the close of another year we meet once more on the anniversary of the Society, to take a brief retrospect of our progress during the past year, and to strengthen, by mutual intercourse, our hopes and our energies for the coming session.

And seldom has the Society met, when such encouragement was more needed. Our country, still weakened by the misery and suffering consequent on its distress, has been visited, in the all-wise dispensations of Providence, with an alarming scourge. Sudden affliction, and unlooked for suffering, have darkened the gloom of the past year; and we meet this evening thankful, I trust, that we have been saved from the unwonted mortality which hovered around us.

The depression caused by suffering, however, and the anxiety for its relief, are not compatible with that undivided attention which Science claims from her votaries; and while most of us may plead our own losses, or the pre-eminent calls of duty to our fellow-sufferers, as abundant excuse for any apparent neglect of our science which may have occurred, we still must look forward to a more successful future, when greater prosperity around us, may enable many who are now wholly engaged in charitable works, to devote at least a portion of their time to scientific pursuits.

It is, however, no small gratification to be able to state, that your Society has not retrograded during two years of severe trial, in which it has had to contend against the great disadvantages consequent on changes in locality and in other respects, and also against those arising from the general state of the country. Your permanent income has been added to—your numbers have not diminished.

I had last year, Gentlemen, occasion to state briefly, the reasons

why in the few words which it was customary for your President to address to you at your annual meeting, I preferred rather to give a brief outline of what had been done in the principal branches of our study during the past year, including the labours of Foreign as well as British geologists, than simply to review the papers read to the Society itself, with the aim of which, I must suppose you are already acquainted; and I further mentioned the reasons why I thought it convenient to subdivide the subject under three or four distinct heads

I regret much that such a sketch must necessarily be very imperfect. There are not sufficient opportunities here of becoming rapidly acquainted with foreign publications: many works published during, and belonging to a former year, have only reached us during the past twelvemonths, yet cannot, therefore, strictly be included among the labours of the year. And even did those means exist, time has been wanting to me to employ them to advantage. The use of the hammer, to a certain extent unfits the hand for wielding the pen; and constant occupation in the field is not calculated to afford either the opportunity or the desire for much reading. Imperfectly, however, as it must be executed, I shall endeavour to outline a few of the more important papers of the past year.

In doing this, however, I would be understood as anxious simply to lay before you the views of the various authors themselves, in a few cases offering a remark or two on the tendency of, or the objections to, such views. And this, not only because I am inclined to think this the most useful plan to adopt, but also because I am satisfied that the occasion of an address like the present is not one which should be made use of by the President for the advocacy of his own peculiar views on any subject. For this there are manifold other opportunities, which appear to me more appropriate.

Adopting, therefore, in some degree the same classification of subjects, as in the remarks I had the honour of addressing to you last year, we have first to notice briefly such papers on descriptive geology, as have, during the twelvemonths since elapsed, tended to throw additional light on our knowledge of the structure or forms of the earth's surface, of the laws which control its variations, and of the distribution of the many members into which its rocky skeleton may be divided.

Early in the year (19th February, 1849,)* M. Coquand gave a description of the primary and igneous rocks of the *department du Var*, in which he proposes to classify all the varieties which occur there into seven distinct groups, viz.—the granites, serpentines, red quartzose porphyries, melaphyres, (including amygdaloids, spilites, traps,) blue quartziferous porphyries, trachytes, and basalts. The granite is not found to occur in large masses, nor forming an independent group, but chiefly in veins and threads in the gneiss and mica slate, and is subordinate to the crystalline schists. To this rule an exception appears in the plains of Tour; but the porphyritic granite of Roquebrune passes, by insensible gradations, into a gneiss, and even leads to a doubt that gneiss and granite are only different forms of the same rock. The gneiss is much more extensive than the granite; in parts it contains so much graphite, that speculators have been led to suspect a coal deposit, and have even made trials for coal. The gneiss rocks are also frequently amphibolitic and porphyritic, and form a passage between the garnet-bearing quartz and the mica slates. To the gneiss succeed mica slates, containing abundantly staurotide, garnet, tourmaline, rutile, disthene, andalusite, and quartz crystals; and containing also subordinate beds of *siderschist*, a mica slate, in which the mica is replaced by fer-oligiste —a variety now for the first time described in Europe. North-east of Collobrieres it is found in strong beds. There are also seen east of Collobrieres garnets, massive—six, and even sometimes thirty feet thick.

Silky slates, (*les phyllades satineès*) form the outer border of the crystalline schists, and are connected with the mica slates by insensible gradations; but between Collobrieres and Hyeres, the argillaceous slates pass into a dark "*coticulaire*" schist, containing rounded grains of quartz, the presence of which would tend to prove that the crystalline character of the schist is a fact posterior to its deposition.

M. De Beaumont had already observed, and the author confirms the statement, that as regards direction, the beds in the Var belong to two groups; one lying north-east and south-west, the other north and south, corresponding to the two systems of elevation established by De Beaumont, viz.—that of Westmoreland and that of the north

* Bull. Soc. Geol. France, page 289.

of England. The crystalline schists are, *par excellence*, tha locality of the quartzose and metalliferous veins.

Of the serpentine there are only three or four masses of any extent. All the serpentine of this district is remarkable, as being entirely free from *diallage*, but is very asbestiferous. It is used for ornamental and other economical purposes. Chromate of iron is found in one or two places, in rognons more or less large. Talc is found interlaced in small threads, like the ores of copper in the serpentine of Tuscany. It is difficult to decide the precise age of this serpentine; but every evidence which there is tends to prove that it is more ancient than the jurassic system, being like the serpentine of the Vosges and of Limousin.

The red quartziferous porphyry forms almost the entire mass of the Esterel, and gives a peculiar physical aspect to it; sharp peaks, and irregular indentations cutting in a hard line against the sky, contrasting strongly with the rounded tops and long slopes around. The valley of Reyrau divides the mass into two parts, or unequal bands. In the constancy of its mineral constituents, this rock forms one of the most marked and best defined terms in the igneous series; and there is as little doubt as to its age, or its relations with the rocks which it traverses or which cover it. The paste is generally a petrosiliceous orthose, of a more or less distinctly red colour, containing numerous simple or hemitrope crystals, of a paler orthose, and also grains of quartz, which in crystalline form approach the dodecahedron. These red porphyries appeared during the period of the *gres-bigarrè*, as is clearly shown by the fact of the lower beds of this group being altered by their contact, while the upper are made up, in a great degree, of the debris of the porphyry itself; and besides, the porphyry has been affected by all the subsequent disturbances of the *gres-bigarrè*.

Under the head of Melaphyres, are included all the varieties of spilites, trap, amygdaloid, wacke, and melaphyres, which may all be taken as one great series, differing in the minerals included; and which might be subdivided into four groups of granular, porphyritic, amygdaloidal, and variolitic melaphyres. Of all these the geological epoch is, according to the author, anterior to, or at least cotemporaneous with, the *gres-bigarrè*. He further thinks, that the successive appearance of dolomitic beds, is in some way connected with the

successive eruption of these melaphyres—not altogether by subsequent alteration, but by the circumstance of the waters at these successive times holding carbonate of magnesia in solution. The melaphyres as a whole, form one geological formation or group, of which the first appearance followed quickly the deposits of the earliest beds of the gres-bigarrè, and which is also connected with the appearance of some metallic veins, and of gypsum and dolomite in Provence and parts of Dauphinè.

The blue quartziferous porphyry, in which the paste is formed of oligoclase, and in part of albite, with dodecahedral crystals of quartz, (which forms one of the essential elements,) the author believes to be the cause of the disturbance of the Esterel.

The trachytic group is very variable in composition; as to age, apparently anterior to the miocene, and posterior to the nummulitic group of the middle of France. The basaltic group is of later date, and produces very marked disturbances and alterations in the rocks adjoining. Of the several facts stated, M. Coquand gives a tabular view, exhibiting the geological period of the production of the several groups of igneous rocks, and the class of veins associated with, and dependent on them.

Large, however, as these masses of igneous rocks are, to get a true notion of their relative importance, we must compare their extent with the area of the seas in which the eruptions occurred; and thus—as the author very justly remarked in reply to objections raised—it would appear that such exhibitions of igneous matter would bear a smaller proportion to the area over which deposits were going on at the time, than the recent cases of the formation of islands in the Mediterranean, would to that sea; and yet no one would expect any appearance of disturbance, other than very local, from such a cause.

M. Daubree has established the very interesting fact, that the granite of the Vosges at Champ du feu, was produced prior to the silurian rocks of that district, in which rolled masses of this granite occur. In those slates fossils are found; while at the other side of the granite mass, slates occur, in which no fossils have hitherto been noticed, which are of a totally different lithological character, and which are traversed in all directions by veins of the granite. There

are thus two distinct systems of slates, intermediate between the deposition of which the granite intrusion took place.*

In two communications† which I myself brought before this Society during the past year, I had occasion to point out the distinct evidence which existed as to the age of the granite rocks of the south-east of Ireland; showing unquestionably that the granite was subsequent to the latest silurian rocks we found in the same district, and long prior to the old red sandstone conglomerates, which in part contained rolled lumps of the granite. If it be sought to ascertain more closely its age, it must be borne in mind, that the only group of the silurian series represented by the rocks in connexion with this granite, is the lowest, or the equivalent of the Llandeilo group; while, at the same time, the occurrence of the rolled masses of granite in the conglomerate of the old red, proves not only the existence of the granite, but further, that it had been long exposed at the surface, and subjected to the action of the degrading and wearing forces, which formed the well rounded lumps we now see imbedded in the sandstones. And in connexion with this I might remark, that in such enquiries regarding the geological epoch at which certain protrusions or intrusions of igneous rocks have occurred, especially of granites, some most important and indeed essential considerations appear to me to be too frequently overlooked The epoch of intrusion is often taken as equally that of protrusion. The time at which the molten matter has been forced into and among the stratified deposits above it, has been confounded with, or even in many cases tacitly assumed to be the same as that at which the same igneous rock has come to the surface, and there become subject to the operation of ordinary mechanical forces. Now, especially in reference to granite, of which we were more immediately speaking, no misconception can possibly be more fruitful of error than this. Independently altogether of the physical impossibility of conceiving a rent in the earth's crust, through which a mass of matter in a state of igneous fusion, extending for some sixty miles in length, and occasionally fifteen to twenty in breadth, (such as that of Wicklow and Wexford) could come to the surface, without—to use the forcible words of

* Comtes Rendus, tom xxix. page 114.

† Jour. Geol. Soc. Dublin: On the Geology of the County Carlow, vol. iv. page 146. On the Geology of the County Kildare, vol. iv. page 150.

Darwin—the very entrails of the earth gushing out, it must be remembered, that nothing is more thoroughly established than this—that the peculiar mineral or lithological character which any of these igneous masses assumes, depends essentially on the peculiar circumstances in which it is placed, or the peculiar conditions to which it is subjected, while cooling. As far as we know, also, certain conditions of pressure and continued high temperature are essential to the production of a granite, which conditions cannot exist at the surface of the earth. Granite, therefore, or in other words, the formation from a molten mass of mineral matter, of that peculiar kind of lithological structure or mineral texture, to which geologists have applied the term granitic, being the result of certain definite conditions, which conditions have not existed at the surface of the earth, the mere occurrence of any mass of granite now appearing at the surface appears to be in itself perfectly conclusive evidence of very considerable changes in that portion of the earth's surface since the formation of the granite; for had the fused or molten mass become subject to the conditions there existing, it would no longer have formed granite, but would have assumed a structure very different indeed from that indicated by this term. The forces which suddenly brought the cooled mass to the surface, may have been of the same kind, or the result of the same general cause; but whatever it were, it must have been exerted subsequently to the consolidation of the mass, under conditions very dissimilar to those which could exist at the surface. While, therefore, the occurrence of granite pebbles in any rock, proves that the granite from which these pebbles have been derived, was exposed at the surface prior to their deposition, their absence, on the contrary, can only be taken to establish the opposite of this, *and even this not conclusively;* but will by no means serve as a proof of the *non-existence* of the granite, or in other words, of the subsequent intrusion of it. We are so very prone to forget the successive and enormous changes through which the surface of our globe has passed, and to reason from tacit assumptions, that the former aspect of that surface has been very similar to its present one, that such a caution appeared desirable. I have felt the necessity of attending to it frequently myself, and I can trace the results of a neglect of such considerations in the statements of others.

Dr. Dale Owen* has published the results of his examination of the northern portion of the United States, up to 49° of north latitude, embracing the Red River, Lake Winnipeg, Rainy Lake, and the northern border of Lake Superior, as well as the St. Pierre River, and its tributaries. Though not entirely completed, he thinks sufficient has been done to prove that there are five or six distinct beds containing trilobites, in the lower group, hitherto supposed to be without any fossils of that kind. These beds are entirely below the lower magnesian limestones of Wisconsin and Iowa, which is the equivalent of the lead-producing limestones of Missouri, and of the calcareous group of New York. Some of the trilobites found are remarkable for their long spiny appendages, occasionally several times as long as the body of the animal.

The devonian rocks described in 1847, as found in the southern portion of the Dubugue district of Iowa, have been proved to extend far up the valley of the river Lower Iowa, and of its tributary, the Red Cedar, and as far as Lime-creek and Shell-creek.

Of each of the subdivisions of the several groups, the author gives a detailed account. Viewed on the large scale, the lower portion appears to be characterized by a series of sandy beds with slaty partings, frequently covered with lingulæ and oboli, and with layers containing abundance of trilobites, at least of individuals; the upper portion is, on the other hand, more calcareous. Working under considerable difficulties, in countries almost inaccessible, much of the journey performed in canoes, carried by the party themselves across the country, frequently withont seeing a human being for weeks, Dr. Owen and his party have thus tracked out the great lines of subdivision of the series of rocks which spread over this enormous tract, and have clearly shown, on the great scale, their relation to, and agreement with, similar groups acknowledged by geologists. They have also thrown much light on the economic relations of the district, and have pointed out the occurrence of numerous veins of lead, &c., a portion of which has been already opened, and with profit.

Professor Nicol† has more fully established the silurian age of the slate rocks of the south-east of Scotland, having discovered graptolites in them in several localities. He has found six species, one of

* Bull. Soc. Geol. France, tom vi. page 419.

† Quar. Jour. Geol. Soc. London, 1850, page 65.

which is new (*G. griestonensis*,) and they all tend to show that these slates belong to the lower silurian, and are equivalent of the Llandeilo-flag series. Mr. Nicol points out the close resemblance which these rocks and their contained fossils have to the silurian rocks of the County of Tyrone, described by Portlock. He gives a rude estimate of the thickness of these deposits, derived from calculating an average dip over a known extent of surface; and supposes that they have a thickness of forty thousand feet. Exceeding caution is necessary in admitting the truth, even as a very rude approximation, of such calculations. Indeed, with the older rocks in these countries, there are very few instances in which they are not more apt to lead astray than otherwise, for they proceed on an assumption which everything seems to disprove, namely, the constancy of dip either as to direction or amount. And I feel perfectly satisfied that many, if not most of the estimated thicknesses of the older stratified rocks will be enormously diminished, when the districts in which they occur are more closely examined. A thickness of regularly stratified deposits of *an uniform average character, and regularly superimposed during the period of the existence of the same group of organized creatures*, amounting to nearly eight miles, is to my mind, an impossibility, or nearly so; inasmuch as the production of such a series must involve such continuous changes of level of land and sea, and such continued and immense degradation of previously existing rocks to furnish the materials, as, under the circumstances of the case, appear to me totally inadmissible.

Professor Nicol derives from the structure of the south-east of Scotland, as he has described it, some very forcible objections to M. Elic De Beaumont's theory of the system of elevations, and further points out the interesting connexion of the position of some axes of elevation with remarkable physical peculiarities, particularly the river drainage. He believes that the very irregular boundary line between the old red sandstone and the silurians in the south, as ontrasted with its nearly straight line on the northern margin, is to be accounted for by the circumstance that the old silurian rocks on the north formed a sea coast, where they were exposed to the wasting influence of an open sea, while the southern portion was being cut into valleys by river action. Professor Nicol concludes his paper by descriptions of the graptolites found in these rocks.

M. Tchihatchef* has given a brief sketch of the results of his long-continued researches in Asia Minor, during which he believes he has established the fact of devonian rocks covering a large portion of that country, and that the "gypsum and red sandstone" formation, the age of which was unknown, contains nummulites; and as to the area covered, is the most extensive formation in Asia Minor.

Mr. Hamilton who, in conjunction with Mr. Strickland, had already contributed much to the geology of other portions of Asia Minor, has now published his observations in the more eastern parts of the country. The extent and variety of the igneous rocks which have pierced and disturbed the area is very remarkable, while the stratified rocks, being for the most part deficient in fossils, it is difficult to give any definite classification of them. He has subdivided them, therefore, into two great groups of secondary and tertiary; the former being of two ages, one the lower secondary, probably representing the jurassic or oolitic system; the other, the upper secondary, probably corresponding to the cretaceous system. Upon them rest the nummulitic group, basins of rock salt, marl and gypsum, and other rocks. The mineral character and arrangement, as far as it could be ascertained, of these several groups of deposits, is described.†

The geology of the several countries visited by the American exploring expedition has been published—a large volume full of details, and illustrated by a volume of plates of fossils. Among other notices, we have from M. Dana an account of the geology of Upper California, which has excited so much of public attention from the abundance of gold found there, and some valuable information on the same district has been also contributed by the Rev. C. S. Lynam.‡

Mr. Dawson has described in considerable detail, the appearance presented by the curious masses of gypsum and associated marls which occur at Plaistercove, in the Strait of Canseau, near Cape Breton, and endeavoured to point out the successive steps in its formation §

Professor Göppert, whose contributions to Fossil Botany are well

* Quar. Jour. Geol. Soc. London, 1849, page 360.

† Quar. Jour. Geol. Soc. London, 1849, page 362.

‡ Sillimans' Journal, 1849, page 290 and 305.

§ Quar. Jour. Geol. Soc. London, 1849, page 335.

known, has published the essay on the coal formation of Silesia, to which the Haarlem Scientific Society awarded its prize. In this valuable work, illustrated with numerous plates of the fossil plants found in the coal measures of that country, the question of the origin of the coal, whether from drifted vegetable matter, or from the decay and subsequent mineralization of plants growing on the spot, is fully discussed; and with more especial reference to Silesia, the distinctive peculiarities of the coal beds in upper and lower Silesia are ably pointed out.

M. Saemaan has given* a general sketch of the relation of the chalk group of the north west of Germany, and of the same formation in France. He considers the *unterer-kreide-mergel* of M. Roemer, to be the true representative of the white chalk, containing *Ananchytes ovata, Terebratula defrancii, carnea, Ostrea vesicularis, Plagiostoma spinosum, belemnitella mucronata,* and a tooth of *mosasaurus.* In opposition to this opinion, was the idea that cephalopods with ornamented septa (*a cloisons decoupèes*) ceased in the upper chalk, while in reality they attain a great size in it. The *ammonites peramplus,* usually quoted to prove the age of this deposit, is not, according to M. Sæmaan, the species known under that name in Touraine, being more nearly related to A. *lewesiensis.* The bed below this in the upper part is full of green grains, of a very marked colour, which gradually decreases in the lower parts. It is very poor in fossils, but contains *ammonites varians,* fortunately characteristic, and which proves it to be the equivalent of the upper chloritic chalk. Next below, we have a compact limestone, grey and marly, much like some of the varieties of the planerkalk of Saxony, and containing many *inoceramus mytiloides.* The lower bed is a grey-brown friable argillaceous sandy bed, not calcareous, containing much pisolitic iron. The lower portion has no grains of quartz, the iron alone forming the base, and it rests directly on the coal measures. This is the *hils conglomerat* of M. Roemer, considered for a long time to be the equivalent of the Neocomian. The fossils from it, however, all tend to show that it is the representation of the *upper* green sand, such as ostrea carinata, exogyra haliotidea, discoidea subuculus; and there is not a single neocomian fossil (*exogyra sinuata,* quoted by Rœmer,

* Bull. Soc. Geol. France, tom. vi., page 446.

being probably a mistake.) The *hils conglomerat* agrees most remarkably with the *tourtia* described by D'Archiac, and to which we referred last year. There are the same terebratulæ; as *T. biplicata, latissima, paucicosta, canaliculata, nuciformis, nerviensis* (longirostris of Rœmer,) *tornacensis, subundata* (Roemer.)

The lower portion of the same group—the *hilsthon* of Rœmer, equally contains no neocomian fossils, according to Sæmaan, nor has he found any trace of the gault in Germany.

Among the most important communications which I noticed last year, it will be recollected was Sir Roderick Murchison's determination of the age of the great and widely extended group of rocks containing nummulites. At that time, this valuable paper had not been published at full, and I was obliged to rest satisfied with brief abstracts. Since then, however, it has appeared, and it is certainly one of the most important contributions to geological knowledge which recent years have afforded, whether we consider the amount of observations grouped, or the importance of the classification now introduced.

For the details of Sir R. Murchison's labour, and the numerous and satisfactory proofs on which he bases his conclusions, I must, however, refer to the paper itself, which will be read with pleasure by every geologist.

Bearing on the same subject, M. Victor Raulin has added to his former communications some additional notes on the nummulitic rocks of the Pyrenees, and has shown that what he had before established for the western portion is equally true for all, viz.—that the cretaceous group is there as perfect in its upper portion, as in the basin at Paris, or at Maestricht; and he thinks there are not even plausible reasons for supposing the *terrain a nummulites* to be any part of it.* M. De Verneuil† has established the range of the nummulitic group in the Asturias, and has there entirely confirmed the views of Sir Roderick Murchison. M. De Zigno, also, in a general sketch of the geology of the Venetian Alps, (in which‡ he

* Bull. Soc. Geol. France, tom. vi. page 531.

† Phil. Magazine, July 1849, page 34. He has also pointed out some peculiarities in the carboniferous group of that country, and states that the coal there is subordinate to the mountain limestone, as in Northumberland and Scotland.

‡ Comtes Rendus, tom xxix. page 15.

states, that by the guidance of fossils alone, he has been able to identify the triassic, lower and middle oolitic groups, and traces of the upper, and to point out the several divisions of the cretaceous group,) has subdivided the tertiaries of that district, which had hitherto been all grouped together, and considered miocene, into eocene, miocene and pliocene; and has satisfied himself that the nummulites are altogether eocene. He corrects an error, into which he had formerly been led by imperfect specimens, supposing that he had found nummulites in the scaglia, and he now thinks that the nummulite is the most characteristic fossil of the eocene group.

The eocene rocks of America have been illustrated by the memoirs of Mr. C. S. Hale, on the geology of south Alabama,* the surface of almost the entire state being composed of rocks referable to that geological epoch; and of Mr. Holmes, who has described the formation on which Charleston, South Carolina, stands. This author also gives a list of one hundred and forty-seven species of post-pliocene fossils from the beds there; detailing at the same time the section of the eocene beds, including the remarkable one in which the *zeuglodon* has been found, and entering into detailed particulars as to the structure and arrangement of the series.

M. Hebert has very carefully examined the fossils derived from the tertiary argillo-sandy beds of Limbourg in Belgium, and thinks that M. Nyst has been in error in referring them to the parallel of the *calcaire grossier*, to which they have but slight analogy, and according to M. Hebert not a single identical fossil. He points out for each species the differences between those assigned by M. Nyst to the Paris Basin, and to the beds of Limbourg. He thinks these beds are really the equivalent of the *ostrea cyathula* beds of the Paris basin, which occur at the base of the fifth group of Brongniart and Cuvier, or the second marine group. This communication, if M. Hebert's results be substantiated by further enquiry, will effect a great change in the classification of the tertiaries of Belgium.‡

M. Prestwich has established the existence of some fossiliferous beds, overlying the red crag at several points in Suffolk, and remarkably contrasting with it by the perfect evidence they afford

* Sillimans' Journal, November, 1848, page 154.
† Do. Do. March, 1849, page 187.
‡ Bull. Soc. Geol. France, tom vi. page

of the quiet and tranquil deposition from which they resulted. The organic remains also, instead of occurring heaped together in confusion, and often fragmentary, as is generally the case in the crag, are regularly perfect, and lie in the position in which the animal lived: the bivalves have constantly both valves together. These sands and clays, from ten to twenty feet thick, are immediately overlaid by the coarse clay-drift. Out of twenty-three species of shells, only one, or possibly two, do not occur recent; all, or nearly all, occur in beds of the age of the Clyde pleistocene beds, and the whole character of the fauna is arctic. The paper is distinguished by that conscientious and accurate attention to detail, and that simple and effective statement of facts, which have characterized all M. Prestwich's communications.

Mr Ringler Thomson* has been led, by the unvarying position in which the bivalve and univalve shells are found in the crag of Suffolk and Essex, to speculate on the cause of this fact. He observes that the countless number of pectunculi and other shells are deposited in layers of various thickness from six inches to as many feet, "each shell having its inside concavity downwards, and the umbones of the shells having in general an easterly direction." He found by repeated experiments, that in waters, whether at rest or in motion, the shells were invariably deposited with their concavity or inside upwards, and univalves with their mouths upwards; and from this not being the case in the crag, inferred that although water may have transported them to their present localities, it could not have been the cause of their actual position. And suspecting the wind might be so, numerous experiments were made, and it was observed, that in all cases the shells, however originally placed, were turned over or came to rest with their concavity downwards, and with their umbones turned towards the point from which the wind blew. If these experiments be considered conclusive, the shells in the crag, which present this remarkable arrangement, must have been left dry, and subjected to the force of a long continued east wind, probably of considerable force. These speculations of Mr. Ringler Thomson. appear to me very interesting and curious, as opening up a class of observations which may, by judicious extension, be fruitful of important deductions regarding the forces which have tended to modify

* Quar Jour. Geol. Soc. London, 1849, page 354.

the disposition of materials on the earth's surface at early as well as at recent geological epochs. On more occasions than one in this Society, and even so recently as in December last, I have had occasion to notice the peculiar character and disposition of some of the sandy masses in the older slates, and to point out how perfectly analogous they were in their arrangement and materials, to many of the sand dunes of the present day, (excepting, of course, their subsequent induration.) And I feel satisfied that many more instances could be adduced, in which the wind, as well as waves, could be shown to have been a very effective agent in producing or modifying geological results. And if in such enquiries, we can derive additional evidence from the position of the fossils imbedded, we most gladly accept the slightest glimmer of additional light, which such observations are calculated to throw on the origin and mode of formation of the masses.

In a brief notice of the tertiary, and some recent deposits in the Island of Nantucket, by Messrs. Desor and Cabot, the authors describe the varying mineral character and position of the beds of sand, gravel, and clay, which rest upon the tertiary clay of that district, and which are considered as forming part of the "drift." And from the similarity of the fossils found in these beds at Nantucket, to those of the newer pliocene of the southern States, the authors conclude that they form a link between the northern and southern deposits; and that, instead of considering them as so many distinct formations, we must henceforth view them simply as modifications of the same great deposit, the result of the same agencies; these being oceanic tide-currents along the whole coast of the United States—local variations being fully accounted for by local changes in the strength or direction of these currents.*

M. Collomb has endeavoured to bring into a chronological arrangement, the quaternary deposits of the valley of the Rhine, more especially with a view to establishing the connexion between those in the plains and those in the mountains.†

In the plains, these deposits consist of two distinct groups—

1st lower, of sand and pebbles.
2nd upper, of sand, clay, and marl, or *lehm*.

* Quar. Jour. Geol. Soc. London, 1849, page 340.
† Bull. Soc. Geol. France, tom. vi. 479.

The lower part is called by M. D. Archiac, the *formation erratique*. The upper has many names, *lehm*, *loess*, diluvium, ancient alluvion, &c., but all authors agree in distinguishing these two groups. In the upper group or *lehm*, ninety-six species of shells have been found by Messrs Braun and Walchner; of these fifty-six are terrestrial, and forty fluviatile; seven belong to living species, and nine others are probably only varieties of living species. Those forms, however which are most common now, are the rarest in the *lehm*, and *vice versa*. The very common recent species, which love warm and dry exposures, never occur in the lehm, while the perfect preservation of the shells proves that they lived where their remains are now found. Besides these, we have remains of *Elephas primigenius*, *Rhinoceros tichorhinus*, *Equus caballus fossilis*, *Bos priscus*, *Cervus euryceros*, and other extinct quadrupeds, the remains of which are very little rounded or altered; and it is not uncommon to find a large portion of the bones of the same animal still united.

In a similar manner the formation in the mountains is composed of two distinct groups, which have a chronological relation with those of the plains, but differ essentially in their composition, their external aspect, and the arrangement of their materials. One of these has been called *terrain erratique*; but to avoid all confusion arising from this name, the author purposes to call it, including the moraines, erratic blocks, and all debris of every kind transported by ancient glaciers, the *terrain glaciaire*. This distinction is especially necessary, as the "terrain glaciaire," and the "terrain erratique" are not cotemporaneous. There is no question that among the mountains, these deposits have had a glacial origin; but the ancient glaciers which formed them have never extended into the plains of the Rhine nor of the Moselle. Besides this glacial formation, there is in all the valleys of the Vosges mountains, another which the author provisionally calls, *formation inferieure*. It fills the lower parts of the valleys—is composed of the same elements as the glacial deposits, but differs essentially from them in the degree of wear of the materials, and in the place which it occupies, being constantly below the other. It is besides always stratified—large blocks are rare, sand and gravel prevail. On this formation, wherever the rock *in situ* is not exposed, rest the moraines.

Above both, there are sometimes turf-bogs, frequently caused by

the glacial moraines having dammed back the water, and caused marshy ground, on which peat grew, and these seem to indicate the termination of the glacial period, and the commencement of the existing order of things. This passage he believes to have been very gradual, but marked by a greater force of watery currents, &c. than at present; this additional force arising, not from the melting of the glaciers—which before this had retired to the limits they occupy at present—but to the naked and unclothed surface of the ground, arising from the action of these glaciers, and before there had been time for it to become clothed again. This state of things has given rise to old torrent beds, in some of which torrents still flow, but in many not.

Such being the deposits in the valleys of the Vosges, what is the chronological connexion between these and those found in the plains? Now the lower deposit of the plains is perfectly continuous with the lower deposits of the hills; it does not differ in the nature of its materials, but only in the mode of their aggregation, being horizontal and continuous in the plains, but in terraces in the hill-valleys. These are therefore identical. The *lehm*, on the other hand, is not so easily traced; it does not spread into the mountain valleys at all, but is constantly separated from the moraines there, by a band of pebbly sand. In fact, the author supposes this *lehm* to be nothing but the mud of glaciers, not deposited or left by the glacier itself, but derived from the glacier, and deposited by water, rivers, &c. in the plains.

Thus we have, as the three necessary results of the existence of these glaciers, the striæ and polishing of the rocks, and the moraines in the mountain valleys, and thirdly, the mud, in what is now called the *lehm*. All the shells found in the latter indicate a period of cold.

M. Collomb therefore concludes, that the two quaternary deposits of the basin of the Rhine, viz.—the lower, or erratic, of M. D'Archiac, and the upper, or *lehm*, in the plains, correspond chronologically with the lower, and with the upper, or glacial, of the mountains—the striæ, moraines, and the *lehm* being the results of one and the same cause, and not separated chronologically.

In connexion with these deposits, M. Scipio Gras has arrived at the following conclusion with regard to the Alps:—

1st. The vegetation which clothed the Alps at the close of the

tertiary epoch, and of which the existence is proved by the various deposits of lignite, as well as various remains of ruminantia and pachydermata, had completely disappeared at the period of the transport of erratic blocks.

2nd. This vegetable denudation confirms the hypothesis of an extraordinary extension of glaciers, covering the Alps, at the epoch of the erratic phenomena.

3rd. Afterwards, by the return of a milder temperature, this covering of snow and ice was removed, and their flanks, then entirely naked, were exposed for a long period to the powerful action of atmospheric causes. It was at this time that most of the deep ravines and funnel-shaped cavities were formed, and the materials produced deposits posterior to the erratic blocks, but still anterior to historic time.

4th. After a considerable time vegetation spread again over the the Alps, and

5th. Finally, Man commenced to inhabit the district.

M. Studer has studied the quaternary deposits of the Tyrol,* where he finds an enormous development of the "erratic block" group composed of gravel and sand. This appears to have filled, before the existent epoch, a large portion of the valleys. There is an immense development of it near Insbruck. M. Studer thinks it evident that these deposits belong to a state of things during which the inclination of the river courses was much less than it is at present; and he supposes the cause of this difference to be a continental elevation, similar to that now taking place in Scandinavia—an elevation quite distinct, however, from that which caused the eastern Alps to appear, since the "diluvium," although raised, is not dislocated, nor have the rocks supporting it suffered any great contortions since its deposit.

Sir Roderick Murchison has discussed the whole question of the character and distribution of the superficial detritus of the Alps, and believes that the physical phenomena of the Alps and Jura are such as to force the geologist to restrict the former extension of glaciers in that country within very much narrower limits than Agassiz, Charpentier, and Forbes had supposed. He shows, from the still

* Bull. Soc. Geol. France, tom vi. page 445.

existing remnants of the water-worn and water-deposited detritus which exist at considerable heights on the sides of the valleys, that water entered into those valleys, then at a considerably lower level (two thousand or three thousand feet) than now. It is asserted that, as each glacier is formed in a *transverse* upper depression, these glaciers have by their movements pushed their moraines *across* the longitudinal valley, and have not united to form one great glacier in it: and thus proving that not even the upper longitudinal valleys around Mont Blanc were ever filled generally with glaciers, he thinks it very easy to show that the lower and great trunk valleys of the Arve, the Doire, and the Rhone, have no trace of moraines, although they contain large erratic blocks irregularly dispersed; all the other detritus is more or less water-worn, and this to great heights above the present bottom of the valleys. He supposes, therefore, that the country of the Alps and Jura has undergone great and unequal elevation since the period of the formation of the earliest glaciers; and that these elevations dislodged great portions of these glaciers, "which floated away many huge blocks on ice," and "hurled on vast turbid accumulations of boulders, sand, and gravel."

All the detritus in the low and undulating region between the Alps and the Jura is water-worn, and does not any where occur as a true moraine, while the great granite blocks from Mont Blanc, which are found on the Jura, appear to Sir Roderick Murchison to have been translated there by ice floats, when all the intermediate country was under water. The surface of the whole country has since been much changed by considerable and irregular elevations.

In this general resumé of the prominent facts regarding the distribution of the detritus of the Alps, Sir Roderick Murchison has thus appealed, in explanation of the phenomena, to the united forces of glaciers and ice-borne materials.

Bearing on the subject of glaciers, we have had a very interesting communication from Mr. John Ball, on the former existence of small glaciers in a part of the County of Kerry. The author describes the phenomena observed in two or three places. On the side of Connor Hill, between Loughs Doon and Beirne, on the steep northern slope of Brandon Hill, above Lough Cruttia, and on the north-eastern side of Purple mountain, Killarney. The several facts were clearly given, and the supposed extent of the glaciers

pointed out, as evidenced by the heaps of detritus representing, according to Mr. Ball, the moraines formerly deposited by these glaciers. From the facts noticed, Mr. Ball concludes, that whatever may have been the climatal condition of this country prior to the existence of these glaciers, the mean temperature at that time cannot have been excessively low, nor such as could have admitted of any considerable extension of glaciers in the adjoining district; for the extent of this glacier at Lough Doon, even under the probably different conditions of elevation of the land above the sea at the time was, according to Mr. Ball, very limited indeed. And secondly, he considers that, therefore, the conditions which gave rise to these small glaciers, must have continued with tolerable uniformity for very long periods; as it must be difficult otherwise to account for the amount of matter in the moraines, considering the slow rate of motion of small glaciers, the limited surface of rock from which the fragmentary materials were to be derived, and the small proportion of those fragments which would be deposited on the lateral moraine.*

The phenomena of striated, furrowed, and smoothed surfaces of rock had been noticed, as occurring in the County of Kerry, many years since, first by Mr. C. W. Hamilton before this Society in 1843, when he exhibited some excellent illustrative sketches; subsequently, Professor Airy had at the Meeting of the British Association, at Cork, mentioned some instances in which similar scratchings had been observed by him. During the past year, Mr. W. C. Trevelyan, has stated, that he had noticed similar polishing and scratching of rocks in several parts of Ireland, as at Limerick, on the cliffs at Kilkee, and at Howth, near Dublin, where the Society will recollect I noticed their occurrence several years since. Indeed it is difficult to conceive how any one could visit some of the districts mentioned, as for instance, the County of Kerry, where the absence of any drift covering allows the surface of the rocks to be well seen, without being at once, and most forcibly, struck with the peculiarly well marked, and beautifully defined furrowing, polishing and scratching, which every surface of rock presents. There is, for instance, scarcely a square yard of rock surface in the neighbourhood of Glengariff, on which such striæ cannot be distinctly seen. The occurrence, however

* Jour. Geol. Soc. Dublin, Vol. iv. page 151.

of these scratchings, over such extended surfaces, at elevations, reaching to even 1,300 and 1,400 feet above the present level of the sea, and at every intervening level, until they are concealed by the water itself, under which they extend as far as can be seen, and the peculiar positions in which such scratchings occur, as I have myself pointed out at Bray Head and Howth, were sufficient to satisfy, at the first glance, any unbiassed mind, that they had not been produced by true glaciers. Mr. Ball, therefore, very justly lays but little stress on such evidence of former glaciers, unless it be found coupled with other proofs. And while, therefore, we are satisfied, that as regards these countries, there is no sufficient evidence whatever to lead us to admit, that either the entire of the surface of this island was at one time covered with a sea of ice, or that glaciers had that enormous extension which has been assigned to them; we are at the same time far from thinking that there have not been true glaciers of limited extent in some of our mountain valleys, which have left unquestioned proofs of their former existence. For directing our attention to some hitherto unnoticed cases of this kind, in which it is probable such small glaciers may have existed, we are indebted to Mr. J. Ball. I see no reason to doubt the probability of such having existed, although they unquestionably appear to me to have been extremely rare, and though many of the instances which have been quoted, have on closer examination been proved to have been of very different origin. The heaps of gravel in Glenmalur I have myself shown not to be moraines. The mass of materials at the entrance, to the valley of Glendalough, on which stands the group of ruined buildings for which it is famous, is another instance of a so-called moraine, but which is undoubtedly the result of the ordinary action of water in forming a bar, by heaping up the detritus brought down by the two streams which here unite, at or near their junction.

There is one point on which Mr. Ball strongly insists—the necessity of admitting the lapse of a long period, for the production of the phenomena presented to us, which is even much more forcibly impressed on us, while considering such masses of water-borne, and water-deposited materials, as that to which I have just alluded.

There is, perhaps, nothing more calculated to give us just conceptions of the littleness of our ordinary times and periods, as compared with the long story of the world, than the contemplation of such a

scene. Before us stand the now ruined remains of buildings, the epoch of whose erection is shrouded in the darkness of antiquity, of whose date we have no record—buildings raised with all the care and skill which the most practised architects of the time could bring to their construction, and designed, by their form, to stand as lasting monuments of the piety of their founders; buildings, too, which have been in a great degree protected by their sacred character, from suffering by the sacrilegious hand of the destroyer. Over their head many a century has passed, and left its withering stains upon their brow, and yet even their date, thus too distant to be reckoned with the accuracy of recorded fact, or classed among historical statements, even this long period will not suffice to be the unit by which we may count back the times and the seasons, during which the same laws of matter, and the same cosmical forces, which now rule the material globe, exerted their untiring sway, and to reach the epoch when that heap of water-borne masses, on which these ruins stand, was accumuated—the measure of the forces which gave it birth, and the lasting evidence of their direction and amount.

Into what a mere shred does the long web of man's existence shrivel itself, when thus exposed to the light of nature's records! What a lesson of humility ought we to learn from this contrast of the unerring decay of man's proudest triumphs, with the lasting destiny of nature's monuments! And yet this, too, but forms a mere page in the long history of former change, and serves but as the record, into which are collected the scattered fragments of the tales which tell of mountains once washed by stormy oceans, and of gorges which once formed the long shores of a troubled sea.

In connexion with this subject, we would allude to a paper by Mr. Charles Maclaren, on grooved and striated rocks in the middle region of Scotland,* a paper distinguished for its candid exposition of the facts, while the author's views are expressed with equal strength and determination. Mr. Maclaren points out the serious objections which many persons have urged against Sir James Hall's idea of such groovings having been produced by the passage of a wave or waves carrying fragments of rocks, gravel, and sand; and he conceives that no agent yet known but ice, or ice conjointly with

* Jameson's Journal, July 1849, page 161.

water, can explain the phenomena; and then proceeds to detail the appearances presented in the several cases of groovings which he has noticed, at nearly thirty different points, shewing that as should be expected, if such groovings were caused by ice-carried agents, the side of prominent rocks which faces the source from which such glaciers have been derived, is always the most grooved and polished. These groovings were also frequently found horizontal on a nearly vertical face, a position in which water-borne materials could not have produced them. Some very interesting cases are given, and well described; and while the author very justly and wisely concludes, that much remains yet to be done before adequate materials for a satisfactory theory are collected, he speculates on the probability of certain results. Thus, the rarety of occurrence of moraines is accounted for by the probability that during the rise and fall of the ocean, deposits of moveable matter, like these moraines must have been frequently swept away.

Mr. Maclaren supposes further, that it is established by the phenomena, that the nucleus of the great force which produced these groovings, or the common centre from which the agents moved, was in the mountains which extend from Lough Goil to Lough Laggan: on the north and west side of which, the striæ are seen to have been produced by an agent moving from the south and east, and on the south-east side, by agents moving from the north and west.

Though a most valuable contribution to our knowledge of the facts, like everything proceeding from Mr. Maclaren's pen, there yet appear to me some assumptions in this paper to which it is needful to allude, in order to guard against the possibility of mistake on the part of future observers. Thus, speaking of the rise and fall of the ocean-level, Mr. Maclaren says, "we have evidence in support of the alleged changes of relative level in the fact, that striæ and grooving certainly produced by glaciers on terra firma, are found covered by the old boulder-clay, which has been deposited from water, and which ascends to the height of 800 feet, at least, above the present seas." Now, Mr. Maclaren appears to have in this assumed two circumstances all-important in the consideration of this question—1st, that the groovings have been produced by glaciers on terra firma; and 2nd, that this grooving has not been cotemporaneous with, or the result of, the formation of the old boulder-clay. If these be

granted as facts, the whole question of the so-called glacial drifts is very much simplified; but these are in reality the very points in dispute, which are assumed as settled. Again, speaking of the smooth side of hills between Garelock and Loch Lomond, at an elevation of 2,400 feet, the author says, he had at the time he first noticed this no authority for concluding that glaciers ever attained the depth of 2,400 feet necessary to cover the ridge on the west side of Loch Lomond. "But this objection is now removed, as the able French geologist, M. Martins, has found traces of an ancient glacier in the Alps, 758 metres, (2,468 English feet,) above the bottom of the valley which contained it. There is no difficulty now, therefore, in admitting that a glacier might abrade the surfaces of the highest of these ridges." In what way, the circumstance stated by M. Martins, even granting it to be an established fact, could prove or support the notion of the existence of such a glacier in the Loch Lomond country, is not to me clear. That glaciers *might* abrade these ridges, no geologist would deny; but the probability of their having ever done so, is only to be proved or established by evidence derived from the district adjoining, and this evidence is no more confirmed by the occurrence of similar phenomena among the Alps, than would the statement of the occurrence of a peculiar kind of rock, (protogene, for example,) in one district, be established by the well known fact of its occurrence in the other.

Nor can the injurious tendency of viewing the phenomena of the so-called drift deposits, only in connexion with, and as illustrated by, the phenomena of glaciers in the Alpine country of the south of Europe, be too strongly insisted on. The area of the earth's surface covered by such deposits, the distribution and limits of that area, and the phenomena exhibited by these formations are all too large, and too general, to derive their elucidatiou from such a comparatively insignificant outlier, as it were, of the phenomena resulting from the action of intense cold, as occurs in the Alps; and the whole range of the Scandinavian phenomena must be grasped by any one who will fairly undertake the subject, as well as those of the glacial district of Switzerland.

M. Visse, in a brief notice of the erratic-blocks of the Andes, near Quito,* has referred to those "fields of stones," or immense trains or

* Comtes Rendus, 1849, March 5th, page 303.

deposits of large blocks, having unquestionably the same mineral structure as the rocks of the mountains adjoining, but at a great distance from them, and their superposition on clayey, or arenaceous deposits. These have already excited much attention; and they have been supposed to be large blocks thrown out by volcanoes. On examining them more closely, however, the author has shown, that they occur for the most part in regular trains, having a definite direction, and are traceable up to the mountains, where they invariably end in a distinct escarpement. The size of the blocks diminishes, as the distance from this escarpement increases: the bands or trains being much more distinct in the higher portions of their line. After a careful search, it is remarkable that the author could not find a single scratched block among them, while all the facts obviously showed, that these trains were not the result of volcanic eruptions.

Another communication to our knowledge of similar phenomena is the work of M. Eugene Robert, forming a portion of the results obtained by the French scientific expedition to the north, in 1835 to 1840. In this M. Robert gives an account of his studies of the last traces which the sea has left on the surface of the northern continents, especially in Europe.

To the results, which he had previously brought forward, and which he has reproduced here, M. Robert adds many others. He has found rocks exhibiting proofs of wear and polishing, from the level of the sea up to 1,170 feet above it: he differs entirely from all previous observers, in stating that the furrowings and striæ are always in the direction of the bedding or lamination of the rocks; and do not occur in granites; and he supposes them due to the greater facility with which the several laminæ degrade on exposure. And uniting with these observations, many from tropical countries as well, he thinks that the whole of these superficial deposits are but terms of one and the same series, and assigns to them all, a common origin; namely, the presence of the waters of the ocean during ages, on surfaces becoming successively less and less deep; and emerging one after the other, either by slight displacements of the ocean from one hemisphere to the other, or by the effect of partial or general liftings of portions of the crust. The presence of blocks he accounts for, by supposing them carried successively by floating

ice, their great development at certain points being due to the length of time elapsed, rather than to any other cause. The striæ, as I have stated, he attributes to the prolonged action of the sea, on the unequally resisting laminæ of the rocks. This latter statement forms one of the most remarkable instances of how completely a preconceived notion can blind the eyes of an observer, that we know of, for nothing can possibly be more perfectly established, nor yet more obvious on the most cursory examination, than that the striation, the polishing, and the furrowing, or grooving of such rocks, is completely independent of their lamination or bedding. Unfortunately such assertions raise a doubt about the truth or accuracy of all the other statements put forward by the author.

While the general question of the distribution of detritus by glacial action has thus engaged much attention, M. Collomb has considered the complicated movement of the larger erratic blocks, which form *tables* on the surface of the glaciers.* The formation of these tables is a phenomenon long known, but the peculiar motion of the blocks has attracted but little attention. These blocks are rarely found on the moraines mixed with other materials. The most beautiful tables occur scattered over the surface of the middle of the *mers de glace;* they are met with isolated, as if thrown at random far from the moraines—they stand alone independent of the long trains of debris, which follow so remarkable a line on the surface of the glaciers. Now these facts of their distance and separation from the other debris, arise from the complication of their movements. This can be divided into *two* parts—one due to the general motion of the glacier itself, the other to that of the block. The author shows, that in proportion as the "table" is elevated from the general surface, the sun acts with greater force on the south side of the block than on the north, which is kept in the shade; and so the supporting ice being dissolved on that side, the tendency of the block, when about to fall, will always be to fall to the south. The motion is in fact double; on the one hand the block is carried by the general movement of translation of the glacier; on the other hand, its own peculiar motion consists of a succession of slips, which complicate the result. Thus a block can form a "table," several times during the

* Bull. Soc. Geol. de France, tom. vi. page 161.

same summer. The removal of the surface of the glaciers in the Alps, in their lower portion, is about four metres in the year; while the height of the supporting column of ice of these tables is seldom more than two metres, so that a block can form a table at least twice in the same year.

Now this being the motion of the blocks, it is clear that if the general direction of motion of the glacier be the same,—viz., from north to south, the blocks must arrive at the terminal talus *before* the other materials; but if the glaciers have a motion in the opposite direction, or from south to north, then the reverse will be the case, as we must then subtract the motion of the table from the general movement of the glacier at large; or supposing the whole motion of the glacier to be fifty yards, and the block to make two slips or falls of two metres each, we would in one of the supposed cases have an actual movement forward of the block, amounting to fifty-four metres—in the other case to only forty-six. It follows also, from this peculiar motion, that a block can start from one bank of a glacier, and after a few years arrive at the other, (provided it does not meet during its progress, with any of those accidents common in glaciers, such as large crevasses or high moraines.) Since if the glaciers have a direction of motion from east to west, or west to east; the line of motion of the blocks will be a resultant of the two rectangular motions, proportional to the mean movement of each of them in a given time.

The author shews also, how the character of the surface as to inclination, and as to exposure, will materially modify such results: and then points out the application of these to the phenomena of erratic blocks, and as tending to explain the exceptions to the general law which M. M. Charpentier and Guyot have established—that the materials are distributed each in their own province; and some cases, where we find larger blocks of foreign matter mixed with the smaller debris. He shews also, the importance of not taking these large blocks as points of observation, in any attempt to determine the motion of glaciers, giving instances in confirmation.

Lieutenant Strachey has brought together many new observations, and compared them with the previously recorded ones, to determine the height at which the limit of the belt of perpetual snow is found in the Himalaya range.* This phenomenon, though not strictly

* Jour. Asiatic Society, Bengal, April, 1849.

geological, becomes to the geologist a very important element in the consideration of the speculations and reasonings which frequently engage him, as to the distribution of heat on the globe, and the consequences of variation in this distribution. Humboldt had already stated the interesting fact, that while on the southern slope or declivity of the Himalaya, the limit of perpetual snow was about 13,000 feet English; on the northern aspect in was 16,600, attributing this greater elevation of 3,600 feet to the conjoint effect of the radiation from the elevated plains of Thibet, and the comparatively unfrequent formation of snow in cold and dry air.

After discussing all the observations, Lieutenant Strachey concludes, that Humboldt has understated the height of the snow line; that it is on the southern side of the chain, 15,500, while on the northern it is 18,500, and that this is chiefly caused by the fact, that a much smaller quantity of snow falls on the northern slopes of the mountains, the winds prevalent there being from the south, which passing over the snowy peaks, become cold and unable to support moisture. Lieutenant Strachey thinks that the radiation from the plains of Thibet has little to do with it, as its effect would be, he thinks, entirely intercepted by the outer flanks of the chain. Captain Cunningham, however, has pointed out, that Humboldt was probably correct, in attributing the difference in elevation, partly to radiation; and that the form of the surface in any great chain is a more important consideration than the latitude, as the snow line constantly recedes, as the ground around the flanks of the chain rises, but with a constantly diminishing rate of difference.*

In connexion with the important subject of the extent, kind, and force of tidal action in modifying or producing deposits of varied character, I cannot forbear referring to a most valuable communication on the Tides of the Irish Channel, by Captain F. W. Beechey,† although not strictly within the range of this address, as the paper was published at the close of the year 1848. This is unquestionably one of the most important contributions to our knowledge of the tidal phenomena of the Irish channel, more especially as these bear

* Jour. Asiatic Society, Bengal, July, 1849.

† Phil. Trans. London, 1848, page 105.

upon geological investigations, that we have had for many years. And although to us, as geologists, this portion of the paper of Captain Beechey may, of course, be considered the most interesting, yet his observations are not without their great value in a commercial point of view, also, as tending most materially to facilitate the navigation of our seas, both by correcting erroneous ideas hitherto prevalent, and by furnishing accurate and sufficiently detailed data for future navigators. In this respect, one of the most interesting of his results is, that the time of the stream is simultaneous, notwithstanding the variety in the times of high water; that the northern and southern streams, in both channels, commence and end, practically speaking, in all parts at the same time; and that this time happens to correspond with the time of high and low water at Morecambe Bay, or Fleetwood. Thus, while it is high water at one end of the channel, it is low water at the other, the same stream making both high and low water at the same time. There are two spots in the channel, in one of which (near Courtown, County Wexford,) the stream runs with considerable velocity, although there is no perceptible rise or fall of tide, and in the other of which (off Dundrum Bay,) the water rises and falls from sixteen to twenty feet, without there being any perceptible horizontal motion.

I cannot possibly detain you by entering into the details of Captain Beechey's paper, in which he describes so graphically the course of the tides as they enter the Irish Channel, both from the north and south, noting the rate of rapidity of the water at the several prominent points. When the detailed charts of these observations shall be published, the connexion of this rate of motion with the character of the sea bottom at distant and varied parts of the channel, will be a question of great and important interest, of which Captain Beechey gives a glimpse in the few facts of the kind he has stated, as, for instance, the fact that the bottom of the space in which there is no perceptible motion, coupled with a considerable rise of tide, (a space of considerable extent between Dundrum Bay and the Calf of man,) is composed of soft blue mud. And another very remarkable fact, that the great body of the northern tide pressing more heavily on the Wigtonshire coast than on that of Antrim, has, in Captain Beechey's words, "*scooped out a remarkable ditch upwards of twenty miles long, by about a mile only in width, in which the depth is from* 400

to 600 feet greater than that of the general level of the bottom about it." Now, whether we fully admit with Captain Beechey, that this has been actually produced by the tidal action, or only suppose that some previously existing valley or depression is by that action kept clear of any deposit, in either case, the geologist will at once recognise the application of such well established facts to his enquiries or speculations regarding the forces which may have produced similar phenomena at earlier periods. And I know of no more fertile subject than this very consideration would open up for any one having time at his disposal for such enquiries; thus, to trace out, by the combined aid of geological and physical researches, the resulting modification as regards tidal action, which must necessarily have arisen from the remarkable and thoroughly established changes of level of land and sea, even in the most recent geological epochs. So early as 1844, I had the pleasure of being the first to lay before this Society maps, in which I had endeavoured to show, roughly, the most remarkable, and at first sight almost incredible, alteration in the general aspect of our seas, which even a change of level of 500 feet in this island would produce; and of pointing out, though briefly and imperfectly, some of the remarkable alterations which from such change must have resulted in the prevailing course of the tidal waters. But I am sanguine enough to hope that, by such enquiries carried out with greater detail, and with the aid of additional data since acquired, some of the remarkable facts relating to the distribution of the more recent deposits in Ireland (those which the French denote *terrains meubles*,) may be reduced to general laws; that precisely as we can now see the cause of the heaping up and accumulation of sandy-banks into Morecambe Bay, so will we be able to trace the general currents, and the direction and force of these currents, which have produced similar accumulations at former periods; and that in this as well as in all other branches of geological investigation, we may much more philosophically and simply explain the phenomena, by a reference to known and existing forces and laws, than by having recourse to any speculation as to enormous climatal changes, or the operation of mighty forces, the former existence of which, to say the least, is doubtful. And to Captain Beechey, I think, geologists are much indebted for the contribution to the data necessary for such enquiries, which his paper affords.

I do not refer to the many other points discussed by Captain Beechey with equal ability, such as the position of the mean water level, the curve or outline of the surface of the tidal wave at different parts of its course, and on different sides of the channel; and the unequal motion of the upper and lower half of the tide wave. These, though they are all points of great interest, do not so immediately bear upon geology.

We would also refer to a very valuable and interesting communication on a similar subject, from Mr. R. A. C. Austen, on the valley of the English channel,* read to the Geological Society of London, in June last. In this Mr. Austen has applied his knowledge of the soundings and bottom of the channel, with great skill, to determine the distribution of materials in that channel, and from this to argue back to the former outline of coast, and afterwards to determine the period of the formation of the channel. I regret much that the details of this paper have only been published within the last few days, so that I am unable to refer to them as fully as I could have wished, and as their great interest to geologists demands.

M. Perrey, to whose continued labours in bringing together, as far as in his power, a complete list of all observed earthquakes, we alluded fully last year, has since published,† in continuation of former lists, one of all the earthquakes which he has found any notice of as occurring in the year 1848. The political and social disturbances so general during that year appear to have prevented many from being recorded. The total number does not amount to more than fifty; of these, the direction of the oscillation of only eleven is given; and the mere fact of a trembling having been observed is in many cases all that has been recorded. The same author has also prepared a list of the earthquakes observed in the United States and Canada, not yet, however, completed. We have also some notices of earthquakes in Assam‡ which appear to have come from the north. The sound wave, was in some cases heard very distinctly three seconds before there was any disturbance of the ground.

The comparative uselessness of such observations, I had occasion

* Quar. Jour. Geol. Soc. No. 21, page 69.

† Bull. de l'Acad. Royale, Bruxelles, 1849, page 228.

‡ Journal, Asiatic. Soc. Bengal, Feb. 1849, page 172.

to insist upon last year, and the necessity for more accurate and systematic observation of earthquake phenomena, is daily becoming more obvious. With this increased necessity, however, we have had increased facilities, and greatly improved methods pointed out. Mr. Mallet has furnished to the British Association during the past year, a very able and detailed report on the statical and dynamical facts of earthquakes, in which he has discussed the several theories of their origin, and clearly enunciated the several conclusions which he considers himself entitled to draw from a review of the whole, supporting each by the details of the cases on which it is founded. As bearing immediately on geology, we will just notice the important conclusion, which necessarily follows from the fact established by Mr. Mallet that the shock or earth-wave is a true undulation of the solid crust of the earth, that earthquakes, however great, are *directly* incapable of producing any permanent elevation or depression on the surface of the earth. *Indirectly*, or by their secondary effect, they may, as by causing land-slips—forming new lakes or river courses—producing fissures, &c., or by the great sea-wave which occasionally results, and which acts with enormous power on the coasts.

Mr. Mallet also discusses the relation of the weather, the state of of the thermometer, barometer, &c., to earthquakes both before, during, and after the actual shocks; and points to the want of correct experiments on the elasticity of the substances forming the earth's crust, and on the rate of transit of the shock through known materials. Mr. Mallet has since been conducting some well devised experiments to determine the latter points, and I believe, with results of great interest. These are not, however, as yet published. I must however, refer to his admirable little essay on the same subject, forming one of those included in the Manual of Scientific Enquiry, published by the Lords of the Admiralty, in which many excellent and simple devices for earthquake observations are pointed out, and clear succinct directions given on points requiring elucidation. And we shall look forward with great interest to the completion of Mr. Mallet's reports and experiments.

Our *palæontological* acquisitions during the past year, have been numerous and interesting. The knowledge already acquired of the forms of organized creatures, of which remains exist in the fossil state, and the comparatively accurate acquaintance with the forms, structures, and habits of existing organisms, which naturalists have obtained during the last few years, have, however, necessarily exerted a very obvious influence on the *character* of such additions to our knowledge; and while we are constantly having new species, or new genera established, or the history of the development of old and well known ones elucidated; while additional facts are being acquired, bearing on the distribution of these genera, whether viewed geologically or geographically, we cannot expect, nor should we look for, such general and striking results, as in the earlier epochs of the history of geology astonished and captivated its students. These great generalizations, essential as they were to the progress of our knowledge, must continually be subject to slight and ever-varying changes, in proportion as we become more accurately informed on the details of our enquiries; and thus it is, that the prominent features being sketched in, it is now the duty of the geological investigator to seek out the minute details, to range these details, each in its peculiar and proper order, and thus, as it were, to bring together and group into general results the statistics of our science. Now though every branch of our enquiry opens up a wide field for the application of this mode of reasoning, and though we are fully satisfied that many important results would be obtained by a more strict and searching reduction to numerical tables of the facts connected with the distribution of minerals, metals, &c., still there is no branch of geological investigation which is more obviously adapted to such methods, than that which concerns itself with the number, variety, and distribution of the forms of organic life, in the several geological groups of stratified rocks. So obvious, indeed, is this, that many writers have already devoted themselves to the collection and collation of such numerical aggregates, and important and valuable results have been obtained.

It may be objected to such enquiries, that with the present imperfect state of our knowledge of the facts of distribution, or even of identification of species or genera, any general results obtained from such imperfect data, must themselves be imperfect. And this is unquestionably true, but true only to a certain extent.

The imperfection of our knowledge on these points, arises from several causes; one of these in the imperfect state of preservation in which the fossils are found. This source of error can readily be eliminated, by rejecting from our calculations all such species as have been named or determined upon such insufficient data. But such cases are extremely few, as compared with the whole number; and a much more fruitful source of error is, that in the majority of cases, the remains of plants or animals, from two or more distinct localities have been identified or described by two or more distinct observers; and we have thus a most important "personal error," introduced into our observations. The chances of this error are happily becoming every day less and less, from the frequent interchange of specimens and opinions among geologists; and this has now been done so frequently and so carefully, that although there undoubtedly are still in our lists of fossils, very many called by different names by different persons, while the fossils themselves are in reality the same, still the total number of such, as compared with the total number of known and acknowledged species, must be represented by a very small fraction indeed, while the rest, forming by very much the majority of the whole, remain as sound and unquestioned data on which the palæontological statist can found his enquiries, and from which he can deduce his results. In several groups, the investigation of which has been specially undertaken by individuals, to whom access had been afforded to the best collections in all countries, the number of such species described under various synonymes by different authors, is very small; as, for instance, in the case of fossil fish. But even taking the group, in which the greatest amount of such confusion is acknowledged to exist, and in the conchylia we have not more than 0.10. to 0.20. which rest under this confusion. Another great difficulty in such investigations, consists in this, that we do not accurately know even the present creation; and still more, that even granting that we know the fossils already discovered perfectly, these said fossils only represent a small portion of the whole which once existed.

In this point of view, the most important contribution of the last few years, has been the very laborious and detailed work of Professor Bronn, in his *Geschichte der Natur*. The amount of labour and detail which he has brought together in this, may be estimated

in some degree from the total number of fossil species which he has enumerated, being 26,421; and in his general tables he has grouped these among the several formations in which they are found, and the several natural history classes to which they belong. It would clearly be impossible in an address like the present, to give even a rude idea of such results, and we must therefore refer to the original work.

Professor Bronn has further taken up some other questions, as the results of these enquiries, and discussed them with some detail. One of these is the "*duration of species*," (*Dauer der Arten.*) After enumerating many cases in which species are known to pass from one formation into another, or even into two or more other formations, he shews that while the duration of species taken singly, may be very varied, still the average or mean duration may be obtained from a large number of such cases; thus as the general result, it is found that out of

	2,055	plants,	12 =	0.06.	Species pass into other formations.
	24,366	animals,	3322 =	0,134.	
Total	26,421		3334 =	0.124.	

Or allowing for the fact that in this the numbers for the plants are too small, and for the animals probably too large, owing to causes which the author points out, he deduces the conclusion, that each species has had an average duration of less than 1.12 formation; remembering at the same time that the occurrence in any one period does not represent an occurrence through the whole of that period, but on the average for a much shorter time. Taking the question of duration of the genera, it appears that there are several limited to a single *formation*, others to a single *period*, consisting of several formations, while others pass through several periods, and some exist at present.

			In different Periods.	In different Formations.	
Thus of	35)	genera of plants,	463	592 times	= 1 : 1.32 : 1.69
	2501	„ animals,	3347	5415	= 1 : 1.34 : 2.17
Together,	2851		3810	6007	= 1 : 1.34 : 2.11

Or in other words—out of 100 genera, 34 per cent. pass into a second period; and 100 genera of plants occur in different forma-

tions, 69; 100 genera of animals, 117; or of both taken together, 211 times.

The author then considers the very interesting question of the number of the species, *(Zahl der Arten;)* or as he puts it—whether (admitting that the actual proportion of the separate divisions of the organic kingdoms to each other has obtained so long as these divisions themselves have existed,) it be possible from the number of still living species to estimate the number of all that have ever existed: in this enquiry, calculating from the number of species preserved in the easily preservable classes, orders, &c., to the number which may have existed in those more dificult of preservation: from the number of parasites, the number of organisms on which they lived, and *vice versa:* supposing a numerical proportion, similar to the present, to have existed between the several groups from their first appearance up to the present period.

Now this proportion of the fossil species to living is thus:—

	Fossil.	Living.	Fossil and Lving.	Proportion.
Plants,	2,050	70,000	72,050	8 : 100 : 103
Animals,	24,000	100,000	124,000	24 : 100 : 124
	26,050	170,000	196,050 =	15 : 100 : 115

that is taking the numbers in round sums, and allowing a little further reduction to be introduced from imperfect specimens, or want of proper identification introducing synonymes.

From this we see, that the number of living animals is not much greater than that of living plants—the proportion being 100 to 70; while the number of fossil animals bears the proportion of 100 to 9 to fossil plants. It must, however, be admitted, that such a proportion, one so widely different from that now existing between these two groups, which have such an important and acknowledged reciprocal influence, one on the other, never existed, and their absence must be due to their being comparatively so difficult of preservation.

In order, however, to follow out the calculation here indicated, it becomes essential to establish first of all, the number of formations which in a palæontological point of view may be considered as reciprocally *equivalent* or of equal value. Professor Bronn assumes of these fifteen, in the whole series. Now though it was previously seen that 12 per cent. of the fossil species passed from one forma-

tion into another, still it must be remembered that by far the larger proportion only continued for a portion, or even a small portion of the duration of that formation; so that estimating all these changes, generally speaking gradual, occasionally sudden, it may fairly be concluded that the mean average *life of a species* was equal to one-half the time of a formation; or in other words, that there have been during the formation of the whole known series of stratified rocks, thirty changes of species, or thirty times the duration or life of a species *(= 30 Arten-wechsel, Arten-dauern, and Arten-Alter setzen.)* Again, in endeavouring to ascertain whether at former periods the earth was as fully or as numerously peopled with species as at present, it is obvious that we can only obtain a fair result by comparing not the entire fossil flora, or fauna with the present, but the fossils of some one locality, (the circumstances of which were favourable for their preservation, and the rocks of which correspond to the duration of a life of a species, or in other words, form a portion of a formation,) with the existing fauna and flora of the same locality; and then combining several such local results, arriving at a general conclusion. Professor Bronn gives instances from all the principal groups of rocks bearing on this question, for the details of which, however, I must refer you to his valuable work, and he concludes from these that although all classes, orders, or families, may not have at all times existed on our earth, though some few groups of them may have vanished, yet that those which then existed were at all times as numerously represented by genera and species as at present. At the same time this did not exclude greater or lesser variations, both in horizontal and vertical direction, and thus many groups might regularly and constantly be more numerously or less numerously represented than at present.

Thus, then, there have been—1st, at least thirty times on the globe a change of species, or thirty "lives of a species." 2nd, during each of these lives of a species, each group in the organic kingdom, which existed at that time, was as numerously represented in former times as now; and 3rd, that notwithstanding the variations and oscillations of several groups, the existing number of the species and genera of each group may be considered as unity, or as the equivalent of each life or duration of a species, *(Arten-alter;)* and these variations, *(Schwankungen)* may even be shown by an exponent placed after the number of existing species.

These exponents clearly cannot be taken with perfect accuracy in the present state of our knowledge; but Professor Bronn has established provisionally for each group its exponent, acknowledging that in some cases it is too high, in others too low; and he thus obtains a general view of the duration and number of the various groups during all geological time. He thus obtains in round numbers 1,500,000 species of animals, and 500,000 species of plants; and it will not in the slightest degree affect the accuracy or the originality and value of Professor Bronn's *method* of arriving at this result whether future corrections increase or diminish this total. Of the 2,000,000 species thus estimated to have once existed, probably not $\frac{1}{10}$ or 200,000 were such as to leave their remains imbedded so as to be recognised, and even of these 200,000, a large portion will never come to our knowledge.

Professor Bronn then enters on the question of the relative richness in fossils of the several periods, (Carboniferous, Triassic, Oolitic, Cretaceous, Tertiary,) into which he divides the whole series. As regards their absolute richness in fossil species, they would stand thus according to

Plants, Cretaceous, Triassic, Oolitic, Tertiary, Carboniferous.
Animals, Triassic, Oolitic, Carboniferous, Cretaceous, Tertiary.
Together, Triassic, Oolitic, Cretaceous, Carboniferous, Tertiary.

He points out fully the difficulty also of saying which period, estimated from time of equal length, was richer, from the many disturbing causes to be considered in the calculation, and from our absolute ignorance as to the existence or non-existence of an uniform proportion between the time and the causes that destroy species, and some other considerations.*

This very brief analysis of some of Professor Bronn's results, will, I hope, be sufficient to indicate the value and importance of his labours. As a work of reference for the student, it is one of the most useful that have issued from the press, and has, as it were, completed for the whole series of fossil organisms, what a monograph on any detached group accomplishes, by bringing together detached and isolated notices, and rendering them all accessible at one view.

* Neues Jahrbuch. Leonhard and Bronn. 2nd Heft, 1849, also since translated by Professor Nicol, in Quar. Jour. Geol. Soc. London. No. 20, Nov. 1849, page 30.

But the work itself must be in the hands of every palæontologist, and I need not impress on them its great value and interest.

If we adopt the plan of grouping the several palæontological contributions, published during the year by the geological succession of the groups of rocks to which they most particularly refer, among the first we would place the fragment of his larger work on the silurian system of Bohemia, which M. Barrande has given us, in which he treats at full, of the successive steps in the development of the species which he had originally (1846) named *Sao hirstua.* In this memoir,* he satisfactorily points out the several stages through which this crustacean passes, the changes in its form, and in the number of rings, or thoracic segments, which are only three in the young state, but increase as the animal grew. The cephalic shield in the young animal constitutes nearly the whole animal, but forms a very small portion of the adult; and so great are these metamorphoses in form, that it is scarcely to be wondered at, that previous writers had classed the several stages under different species, and even genera. In fact, Barrande has reduced to the one species of Sao hirsuta, no less than twenty-two species described under thirteen different genera.

These metamorphoses have a remarkable interest also for the physiologist, bearing on the question of the affinities of these crustaceans as indicating their embryonic state ; and judging from this fragment of his larger promised work, M. Barrande's labours will, doubtless, throw much light on the fossil history of the earlier geological epochs.

During the past year, two decades of fossils have been published in connexion with the Geological Survey of the United Kingdom, one of which (No. 2,) is devoted to trilobites ; and here also we have a notice of a somewhat similar metamorphosis in another genus of this interesting class. Mr. Salter has observed in the species which he has named *Ogygia Portlockii*, that the youngest specimen found has only four thoracic rings, while others more fully grown have seven and eight. We may be allowed here to direct attention also to the extreme beauty and accuracy of the illustrations published in these decades, in the engraving of which, advantage has been taken of the facilities afforded by the modern improvements in steel engrav-

* Leonhard and Bronn, Jahrbuch, 4th part, 1849, page 885.

ing, so that the most perfect effects of tinting is produced, while the lines employed to produce the effect of form, do not in the slightest degree interfere with those used to represent structural markings.*

Mr. M'Coy, in a paper on the classification of British fossil crustacea, &c., has not only described several new genera (*Chasmops, Trimerocephalus, Barrandia, Tretaspis, Harpidella,*) and species of trilobites, but has also given some general views on the classification of the whole family. As the chief ground of his subdivision he takes the character of the *pleuræ*, or lateral portions of the thoracic segments; and he adopts five sub-families to include the whole group. Taking into consideration the remarkable facts we have just noticed, as established by the researches of Barrande on the metamorphoses of trilobites, it may fairly be questioned whether many of these divisions will not be necessarily modified by the progress of investigation, although such changes will not detract from the present value of these classifications.

Mr. M'Coy has further examined the homologies of the cephalic portion of trilobites, and the much discussed "facial suture." He considers the cephalic shield as composed of an extension of the two first cephalic rings, the facial suture itself being the line of separation between the first and second cephalic ring—the portion bearing the eyes, or that anterior and external to the eye line, being the first or opthalmic ring, as in other crustacea. Such is Mr. M'Coy's view, in support of which there is much to be said, although there are also several important difficulties in admitting it. The character of the *pleuræ* is also more fully described than they have hitherto been, and they are divided into two groups—facetted and non-facetted, the *facet* being "the smooth flat triangular space at the extremity of the anterior margin of the pleuræ of certain trilobites." The paper also contains valuable remarks on some other families of crustacea besides the trilobites.†

M. Marie Roualt, has described and figured a new trilobite of the genus Lichas (*L: heberti*) from the schists of Vitre, in Britanny, in which he announces the discovery of *Homanolotus, Ogygia, Illænus,* &c.‡

* Memoirs of the Geological Survey of the United Kingdom. Figures and descriptions illustrative of British organic remains. Decade 2.

† Ann. Nat. History, Dec. 1849, page 392, &c.

‡ Bull. Soc. Geol. de France, March, 19, 1849, page 377.

Mr. Fletcher of Dudley, whose very beautiful and perfect collection of the fossils of that neighbourhood is well known, has recently described some species of Lichas from Dudley.*

Mr. Davidson has added to his former valuable descriptions of the Brachiopoda, figuring a new species *Leptœna grayi.* He questions further the propriety of grouping under one species, (as Mr. Salter had done,) *Orthis rustica, walsali,* and *calligramma,* thinking, with M. De Verneuil, that *O calligramma* does not occur in England. In the same paper he describes a new species, *Leptœna granulosa* from the marlstone of the lias near Ilminster, found associated with *Terebratula pygmœa,* which latter also occurs in France associated with *Lep : liassiana.* This is an interesting discovery, and with the other species already described from the lias, (viz. *Leptœna liassiana, bouchardi, moorei, pearcei,*) prove that the genus leptœna, supposed to have died out with the palœozoic rocks, has really continued to exist, although in small number and of minute size, in the newer deposits.†

Professor M'Coy has described a considerable number of new Palœozoic Echinodermata, principally derived from the carboniferous limestone of Derbyshire and Yorkshire. We have to regret the absence of any figures of the fourteen new species established, some of which are, however, well marked and will be recognizable.‡

Sir Philip Egerton has continued his valuable additions to our knowledge of fossil fish. In his Palicthyologic notes, (No. 2,) he proved that the genus Platysomus of Agassiz must be classed with the *Pycnodonts,* not the *Lepidoidei,* and that the *globulodus* of Münster is a true *platysomus,* so that his genus must be cancelled.§ And in No. 3 of his notes, he has given a general survey of the heterocerque ganoids—describing and figuring some new species.‖

M. L. Abbé Danielo has found vast numbers of the curious, and hitherto little known remains, called *bilobites* by Cordier; and he has come to the conclusion that they are distinctly vegetable. They occur in beds associated with others containing Arca, modiola, tere-

* Athenæum, Jan. 19, 1850.

† Bul. Soc. Geol. France, tom vi. page 271, Feb. 5, 1849.

‡ Ann. Nat. Hist., April, 1849, page 244.

§ Quar. Jour. Geol. Soc. London, 1849, page 329.

‖ Quar. Jour. Geol. Soc. London, 1850, page 1.

bratula, &c., and which he considers to belong to the Devonian groups, in the department of Morbihan.*

Mr. Morris has announced the discovery of a species of Siphonotreta, (*S. anglica*, Morr,) in the Wenlock shale of Dudley.†

The discovery by Mr. Isaac Lea, of the foot-prints of reptiles in the old red sandstone at Pottsville, Pennsylvania, consisting of six distinct markings in a double row, is another very interesting addition to our knowledge of the distribution of animal life in the stratified rocks. Until very recently, as you are aware, no reptile forms had been observed in any rocks older than the Permian group, but Goldfüss had found two skeletons of reptiles in the coal formation near Treves; and Dr. King, in America, had also found foot-prints of a reptile in the western coalfield; and now Mr. Lea has shewn the existence of these air-breathing animals at an earlier period in the old red sandstone epoch. He proposes to name the animal whose tracks upon the sand are thus so wonderfully preserved—*Sauropus primævus*.‡

In connexion with these foot-prints we would notice an elaborate and detailed account of all hitherto described, illustrated by numerous plates—(128 pages, and 24 plates,) by Professor Hitchcock, President of Amherst College. He describes fifty-one species in all—of which twelve are quadrupeds, four of lizards, (?) two chelonian, six batrachian, two mollusca or annelida, thirty-four bipeds, three doubtful.§

Mr. Binney, who has already contributed so much to the history of those remarkable fossils, the *Stigmaria* and *Sigillaria*, has more recently found Stigmaria, in the middle of a seam of coal, full of the spores of the lepidostrobus, an important and additional fact in their history, as bringing the two together. It may be remembered, that in the case of the Dixon fold trees, described by Mr. Bowman, and which were by him considered to be Sigillaria, there were numerous lepidostrobi lying around their roots. Mr. Binney's specimens were derived from the so-called "brasses," or lumps of iron pyrites, which abound in the "King coal" at Wigan, and which have to be picked

* Comtes Rendus., 26 March, 1849, page 415.

† Athenæum. Brit. Ass. Report, page 992.

‡ Brit. Ass. Report. Athenæum, page 937, 1849.

§ American Academy Transac., Boston, 1848, vol. iii., 2nd series.

out before the coal is sent to market. In the centre of these "brasses," Mr. Binney frequently found a stigmaria, composed of clay ironstone, generally much compressed, but occasionally so preserved as to exhibit their original round form, and their structure. Mr. Binney also states, that after careful examination of many specimens in situ, he has not been able to confirm the idea of their being a true *taproot* to Sigillaria.*

In this latter circumstance, Mr. Binney differs altogether from Mr. Brown, who has described some erect Sigillaria with roots in situ, found in the roof of the Sydney Main coal, in the Island of Cape Breton; the stem, and roots attached, were found in their place of growth, rooted in a bed of hard shale covering the coal. On carefully clearing out the under surface of the fossil, Mr. Brown found that the horizontal roots branched off in a very regular manner, the base being first divided into four quarters, by deep channels running from near the centre outwards—(the "crucial suture" of J. Hooker?) an inch or two further from the centre, these quarters are again divided into two roots which themselves bifurcate again, so as to produce thirty-two roots in all, within a circle, in Mr. Brown's specimens, of eighteen inches diameter. In each quarter of the stump, there were four large tap roots, one on each rootlet, and beyond these, about five inches, another set of smaller tap roots, so that there were forty-eight in all—viz., sixteen in the inner circle, and thirty-two in the outer. Mr. Brown points out the curious correspondence between the number of the roots, (thirty-two,) and the vertical rows of leaf-scars on the stem, (also thirty-two,) and infers from the character of the roots, and their peculiar position with regard to the beds of shale and coal, that the plants to which they belonged were adapted for living in a soft muddy soil. He also shows that the remarkable "dome-shaped" fossil figured by Lindley and Hutton, is nothing but a similar root of Sigillaria, with the stem broken off.

The roots of these large sigillariæ were found not to cover an area of more than thirty square feet; while the roots of lepidodendron, which the same author previously described, and whose stem was only two or three inches in diameter, covered an area of two hundred square feet. Now the lepidodendron were lofty trees with spreading branches; and he concludes from this proportion in

* Quar. Jour. Geol. Soc. London, Feb. 1850, page 17–21.

the size of their roots, that sigillariæ were, on the contrary, trees of low growth, and without spreading branches.*

A very important contribution to the knowledge of fossil fish has been made by Mr. W. C. Williamson, in his memoir on the microscopic structure of the scales and dermal teeth of some ganoid and placoid fish.† After reviewing the opinions held by previous investigators, Mr. Williamson gives the result of his examination of the scales of the genera *Lepidosteus*, *Lepidotus*, *Seminotus*, *Pholidotus*, *Ptycholepis*, *Beryx*, and *Dapedius*—all of which seem to be constructed after one common type, with modifications. Another group of structures was found in *Megalicthys*, *Holoptychius*, and *Diplopterus*. Many others were also examined, and the structure of their scales is given in detail, and very fully illustrated. The author concludes from all, that what has hitherto been called enamel, is in fishes a compound structure, separable into two—ganoine, and what he calls kosmine; the former being superficial, transparent, and laminated, but otherwise without structure; the latter consisting of minute branching tubes, resembling the dentine of true teeth;—that the kosmine covering the osseous scales of many ganoid fishes is homologous to, and identical with, the substance forming the dermal teeth of placoids, so that the distinction of ganoid and placoid can scarcely be retained as a physiological one; and that the ganoid scales consist of variously modified osseous lamellæ, successively added chiefly to the lower surface, but also occasionally to a part or the whole of the upper surface. He shows also, the mode in which these lamellæ have been formed, and points out the advantage of using the microscope as a means of distinguishing genera and species, and also of establishing their affinities, wisely cautioning against the danger of urging such investigations too far, without giving full weight to the importance of the other portions of the fish to which these scales belong.

As connected with the palæontology of the older rocks, we must also refer to the publication of the geological investigations of the American exploring expedition, illustrated by a large folio volume of plates. Many of the fossils figured have been already described

* Quar. Jour. Geol. Soc. London, 1849, page 354.

† Phil. Trans. London, 1849, page 435.

by Count Strzelecki and others; but the work contains also numerous additions to those previously published.

M. Bayle has announced the occurrence in the well known beds of Saint Cassian, of a mixture of palœozoic and mesozoic species; of fishes, there are species of Gyrolepis, Hybodus, &c.; of cephalopoda —Orthoceras, Goniatites, Ceratites, Ammonites; also Bellerophon, Porcellia, Nucula, Trigonia, Terebratula, Spirifer, Producta (leonhardi) Cidaris, &c. He considers the beds as an intermediate term, belonging, however, to the *marnes irisees.**

The fossil fish of the Muschelkalk of Jena, Querfurt and Esperstädt, have been described by Von Meyer, who has also published the fish, crustacea, echinoderms, and other fossils of the same rock, at Oberschlesien.† In this monograph, which is very well illustrated by finely drawn and neatly printed figures, he describes twenty species of fish alone, belonging to the genera Leiacanthus, Hybodus, Acrodus, Palæobates, Saurichthys, &c. &c.

The fossils of the Muschelkalk of north-west Germany, have been investigated also by Von Strombech, in an excellent memoir, published in the Proceedings of the German Geological Society. In this communication, the important point of the distribution of the species is particularly attended to.

The fossils found at Spitzbergen, and referred by their finder, M. Eugene Robert, to the carboniferous group, have been shown by M. De Koninck really to belong to the Permian series, or the Zechstein. Among them were *Spirifer undulatus*, *Productus horridus*, *P. cancrini*. Some of the species of spirifer belong to the genus spiriferina of D'Orbigny, having their shells perforated; of which subgenus none have as yet been found in the carboniferous group.‡

Mr. Morris, whose accuracy and research are so well known to, and so highly appreciated by, all British palæontologists, has described a new genus of shells from the secondary strata, to which he has given the name *Neritoma*, differing from the true *neritæ*, with which they had previously been associated, in having on the outer lip two sinuses more or less deeply marked, and also in the

* Bull. Soc. Geol. de France, 5th March, 1849, page 323.

† Dunker und Von Meyer, Palæontographica, 1 Band V. lief, page 195—216.

‡ Comtes Rendus, and Bull. Soc. Geol. de France.

form of the aperture and the columellar lip. Mr. Morris also points out the interesting fact, that this group of shells forms a distinct generic type, and adds another instance of molluscs, which, with analogous forms, have yet a distinctive character similar to Neritoma, in possessing a greater or less sinus in the outer lip. And in grouping such genera with their analogues, it is remarked that most of those which have this sinus belong to extinct genera. Thus *Acroculia, Murchisonia, Platyschisma,* found in the palæozoic rocks, are represented by the analogous existing genera without sinuses, of *Pileopsis, Cerithium,* and *Trochus. Neritoma* in the secondary rocks, by *Nerita* existing, &c.*

Mr. King, whose catalogue of the Permian fossils of Northumberland, &c. is in the press for the Palæontographical Society, has given a brief summary,† but without any illustrations, of some of the families and genera of corals of that group, describing six new genera. It is impossible to say how far such divisions are well grounded or not, until the details are given; and the very important changes which have been introduced in the classification of the coralline fossils, as more perfectly preserved or more numerous specimens have been examined, should render us extremely cautious in admitting any subdivisions which are not grounded upon sufficient data. In the group of corallines especially, it appears to me that great impediments have been thrown in the way of the progress of sound knowledge, by a heaping up of names of genera and species, most of them described from very small and, in many cases, imperfect fragments, which cannot possibly afford any information as to the habits of growth of the coralline, and but a very imperfect insight into its structure. I have had occasion years since to point out some instances of confusion arising from these causes, and am still even more convinced of the necessity of great caution, and the possession of good, and even numerous specimens, before venturing on any new classification of the forms found in the fossil state.

In connexion with Zoophytology in general, the extremely valuable, and ably illustrated papers of M. Milne Edwards and Jules Haime, which continue to enrich the pages of the *Annales des Sci-*

* Quar. Jour. Geol. Soc. London, Nov. 1849, page 332.

† Ann. Nat. His. May, 1849, page 388.

ences Naturelles, must be referred to as among the most important contributions to fossil Zoophytology, which have ever appeared.

The very remarkable and curious batrachians, known to geologists under the name of *Labyrinthodon*, have been beautifully illustrated by Burmeister, in a monograph on those found in the bünter-sandstein near Bemburg.

Dr. Lloyd has also described the remains of a new species, which he has named *Labyrinthodon Bucklandi*, from near Kenilworth, Warwickshire. The specimen exhibits a skull compressed between two layers of sandstone, and having twenty or more teeth in the maxillary bone. Dr. Lloyd thinks the bed in which this specimen was found is undoubtedly to be referred to the same subdivision as that from which Burmeister's specimens were derived—the bünter-sandstein; whereas those previously found in the same neighbourhood were from the white sandstone of Warwick, which has been rather uncertainly referred to the keüper.* Mr. Sanders, at the same meeting of the British Association, gave some reasons for considering that the beds in which the remains of the Thecodontosaurus and Palæosaurus were found at Durdham down near Bristol, belonged not to the lowest portion, but rather to the latest period of the new red sandstone.

In the first part of a paper, already referred to, by Professor M'Coy, we have some valuable additions to our knowledge of the structure and forms of fossil crustacea, from the newer secondary and tertiary rocks. In this communication, the Professor has formed eight new genera for the reception of these crustacea, and thirteen new species. Some of these being illustrated by well executed woodcuts, the paper forms an important addition to our knowledge of a group of fossils, frequently preserved with great perfection, and which have hitherto not received much attention from British palæontologists.†

Dr. Mantell has added considerably to our acquaintance with the structure of the wealden reptiles, in his description of some additional specimens of the *Iguanodon* and *Hylæosaurus*, the most important portion of which is the determination of the vertebral

* Athenæn. Brit. Ass. Report, 1849, page 992.

† Annals Nat. His. Sep. and Nov. 1849.

column, pectoral arch, and anterior extremities of the Iguanodon. The vertebral column presents the interesting fact of having the anterior dorsal and cervical vertebræ convexo-concave; that is, convex in front, and concave behind, (as in the remarkable reptile called *streptospondylus,)* but this convexity of the anterior side, or face of the body of the vertebra gradually diminishes, and it becomes flat in the middle and posterior part of the dorsal region. Dr. Mantell considers the vertebræ referred by Owen to Streptospondylus major, (British Association report on fossil reptiles,) to be in reality cervical vertebræ of the Iguanodon, and some of those referred to *cetiosaurus,* as being posterior dorsal, and lumbar vertebræ of the same reptile. The sacrum, the pectoral arch, and the humerus, are also described at length: and Professor Melville's able anatomical remarks are appended. It has thus been Dr. Mantell's good fortune, after the lapse of quarter of a century, to complete the description of the gigantic saurian, which he had himself first noticed from a few "isolated and water-worn teeth"—a well earned, and well merited reward of the untiring zeal and energy with which he has pursued his researches.*

M. Saemann, in some observations on the family of Rudista, has given the results of his careful examination of numerous specimens, (especially with reference to their internal structure,) of Sphærulites and Hippurites, and has perfectly established the existence of distinct hinges, and muscular attachment of a peculiar kind, which places the question of the classification of Hippurites, in which the structure of these parts was not previously known, beyond a doubt, and shows that they belong to the Ostracea, with which group Deshayes has previously ranked them.†

From M. Soriquet we have a complete list of all the Echinida found in the cretaceous group of the department de l'Eure, useful for comparison with other districts, all of these amounting to seventy-four species, having been determined on the high authority of M. Michelin. Of these seventy-four species, three only are stated to be common to the white chalk, and the *craie chloriteè.*‡

And from the Geological Survey of Great Britain, we have in the

* Phil. Trans. London, 1849, page 271.

† Bull. Soc. Geol. France, Feb. 1849, page 280.

‡ Bull. Soc. Geol. France, April, 1849, page 441.

first decade of fossils, beautiful figures and descriptions of a number of Echinoderms. Professor E. Forbes has here given all the known British silurian species of asteriadæ, some new forms of oolitic, and all the London-clay star-fishes; together with six plates of fossil Echinidæ. The extreme beauty and admirable preservation of the Echinidæ, are well known to every one who has ever examined a collection of oolitic or chalk fossils, and the importance of a careful investigation of their forms, and an accurate determination of the species, subject in several cases to much variation in size and form, cannot be too highly estimated. The fact that some even of the most ordinary occurrence have been described under seven or eight different names, is in itself sufficient to show the value of such a general review of the group.

Professor Owen has given a brief but very important description of some reptile remains, from the Greensand of New Jersey, discovered by Professor Henry Rogers. They consist of crocodiles of two species, belonging to the same genus, as existing crocodiles or alligators, and which Professor Owen has named *Crocodilus basifissus*, and *C. basitruncatus*: of remains of a mosasauroid reptile, allied very closely to the Leiodon, for which Professor Owen has proposed the name of *Macrosaurus*; of true mosasaurus remains of the species, *M. Maximiliani*: and of teleosauroid remains, referred to a new genus, *Hyposaurus Rogersii*.* Although drawn up under most disadvantageous circumstances, resulting from the unfortunate loss of his original MSS. containing the detailed observations, a loss which every palæontologist must most deeply regret, this brief communication forms a very important addition to our knowledge of reptile life, during the earlier periods of the cretaceous epoch.

The fossil sharks of the United States, have been monographed with good figures, by Dr. Gibbes of Columbia, South Carolina.

Passing to the tertiary rocks, Dr. Carpenter, whose researches on the microscopic structure of shells are well known, has applied the same method of investigation to the examination of the intimate structure of the nummulina, orbitolites, and orbitoides, and has given a detailed and careful description of his results, accompanied by good figures.† His

* Quar. Jour. Geol. Soc. London, 1849, page 382.
† Quar. Journ. Geol. Soc. London, 1850, page 21.

observations entirely support the view that nummulina belongs to the foraminifera, as also the orbitoides of D'Orbigny; while he doubtfully refers the orbitolites to the *Bryozoa*. Whether this conclusion may be finally established or not, Dr. Carpenters' researches have laid before us some of the most beautiful structures as yet known, and we hope that with the experience he has already acquired in the use of the miscroscope, he may be induced to pursue such enquiries, and bring the same accuracy of observation to bear on the minute structures of other organic forms.

The Palæontographical Society have, during the past year, issued a most valuable monograph of the chelonian reptiles of the London clay, drawn up by Professors Owen and Bell, illustrated by thirty-eight very excellent plates and some wood-cuts. In this monograph we have detailed descriptions of eleven species of Chelonia, eight of Trionyx, two of Platemys, and six of Emys, in all of twenty-seven species from this one formation alone, the eocene tertiary of England.

This publication, taken in connexion with the able paper by Professor Owen, in which he discusses generally, the homologies and development of the carapace and plastron of the Chelonia,* leaves little to be desired with regard to this family of fossils, and renders perfect up to the present time, our knowledge of the several species found in our eocene deposits.

From the same Society we have also the first part of a monograph on the mollusca belonging to the same geological formation, including the *cephalopoda*, drawn up by M. F. Edwards. Thirteen species are described and figured; a very large number of synonymes being reduced to this number. These two well illustrated monographs furnish an amount of information regarding the fossils of our eocene deposits, which could not have been obtained previously, except by minute, tedious, and detailed research.

Reuss and Von Meyer have jointly contributed a valuable paper on the tertiary fresh water formations of Northern Bohemia*—formations remarkable for the number of beautiful land-shells contained in them, all apparently new.

Mr. Carrick Moore† has described some tertiaries in the Island of Saint Domingo; noticing four species of foraminifera, and seventy-

* Von Meyer, Palæontographica, 1849.

† Phil. Transac. London, 1849, page 151.

seven of mollusca which occur in them, besides fishes' teeth, (*Carcharodon megalodon*, Agas) corals, and one echinoderm, (*Scutella.*) Of the shells, thirteen are identical with existing species, and two are doubtful—fifty-nine are considered new, and descriptions given, with figures of some. From a review of the whole evidence, Mr. Moore considers these deposits to be of miocene age. A very remarkable and interesting circumstance connected with these deposits, is the striking resemblance which many of the shells have to recent species which inhabit the seas of China, Australia, and the western coast of America. One is identical with an Indian Ocean species, (*Venus puerpera* Linn,) and another (*Phos Veraguensis*) is found in the bay of Veragua, on the eastern side of the continent. Now, the tertiary beds which flank the Cordilleras, have not one single species in common on the two sides.—(D'Orbigny.) In the North American miocene beds, all the species, which occur also recent, are without exception Atlantic species, while in this case we find two species, now found recent only in the Indian and Pacific Ocean, occurring in a fossil state in beds connected with the Atlantic. Mr. Moore accounts for this by pointing out the narrowness and lowness of the land in the Isthmus of Panama, which no where attains an elevation of more than 1000 feet; and thinking that a connexion between the two oceans might have existed here in the equatorial regions, long after a separation had taken place more northerly and southerly, where the range of the Andes presents points of 4,500 feet elevation and more.

A somewhat analogous case of the occurrence of fossil remains of peculiar character, pointing to former connexion of districts of the earth's surface, now, and long separated, is pointed out by M. Gervais, who announces the very interesting discovery of the remains of elephants and mastodons in Algieria. Of the elephant, the remains found are referable to the species *primigenius*, of which Sicily has hitherto been the most southerly limit; of the mastodon the remains are more nearly allied to the *M. brevirostre*, which is pliocene, than to M. angustidens, which is of miocene age. Many of the terrestrial and fluviatile remains of the south of Europe and north of Africa agree—the existing fauna and flora agree—and belong to the same centre of creation; and the finding in the fossil state, in caves in the south of France, of animals which still exist on the coast of Barbary, mixed with others which

† Quar. Jour. Geol. Soc. London, 1850, page 89.

belong to the basin of the Rhone, is another important fact, which, coupled with these recent discoveries of mastodon and elephant remains, is of peculiar value as bearing on the question of the former connexion of the south of Europe and the north of Africa during the recent portion of the tertiary epoch.*

The same author has carefully investigated the mammalia of the genera Palæotherium and Lophiodon, met with in the south of France. He has found that among these are several found in the eocene-beds of the Paris basin, as P. *magnum, crassum, medium, curtum, minus. Anoplotherium commune*—the other species being principally new, and therefore of no value as evidence of age. From these facts, he concludes that the beds in the south of France are of the eocene period, and not miocene, as hitherto supposed. He thinks that the genera Paloplotherium, (Owen,) and Plagiolophus, (Pomel,) have no sufficient grounds, and are in reality Palæotheria. With regard to Lophiodon, after pointing out some distinctions in their character, which he thinks sufficient to warrant a new arrangement of them, he asserts, that the Lophiodons, and the animals found with them, constitute a distinct population, their remains being found in very varied mineral beds, clays, sands, limestones, &c.; but though difficult to decide exactly, he is inclined to think them all eocene.†

M. De Christol has considered the general classification of the Pachyderms, and divides them into two great groups, according as they have molar teeth, with or without cement. The acementodont pachyderms do not differ from the others in this respect only; but this is considered the most essential distinctive point. The differences are fully pointed out, and the author concludes from the examination of the two parallel series, into which he divides the whole order, that in all the families of the order of pachydermata, the acementodont group is more ancient than the cementodont.‡

M. Christol§ has also announced the finding, in the marine sands of Montpelier, (in which the metaxytherium cuvierii occurs,) of several bones of the limbs of an ape, (*Pithecus maritimus*—Christol,)

* Comtes Rendus, tom xxviii., 12th March, 1849, page 362.

† Com. Rendus, tom xxix., Oct. 8, 1849, page 381,

‡ Comtes Rendus, tom xxix., page 368.

§ Bull. Soc. Geol. France, tom vi. page 169.

also a felis with cutting, and strong canine teeth, to which he has given the specific name of *Felis maritimus*, and some other interesting remains.

Messrs. Dubreuil and Gervais have discovered in the salt-water molasse of Castries, in the department of Herault, the nearly entire coronoid bone of a dolphin, nearly as large as the *delphinus rissoanus or griseus* of the Mediterranean, but differing entirely from them, from another dolphin found in the blue molasse of Vendargues, from the squalodon of Bourdeaux and of Malta, and from all known delphini, by its teeth, which are very broad as compared with their length, from which circumstances the authors have given it the name of *Delphinus brevidens*. In the same rock, they have also found the *Myliobates micropleurus* (Agas.)*

Giebel† has given a list of the animals, whose remains are found in the cave called Sandwicker-höhle, and the occurrence of a bird's egg in the tertiary limestone of Weissenau, near Mayence, is stated by Becker.‡

Professor Nillsson of Lund's valuable researches, in the history of the recent and extinct bovine animals of Scandinavia, have been given to the English reader in the Annals of Natural History,§ and will be found particularly interesting to the Irish observer, from the comparative abundance in this country of the remains of some of the species described.

The Rev. W. Smith has described‖ the occurrence of an earth very rich in diatomaceæ, on the banks of Lough Mourne, near Carrickfergus, in which he has noticed no less than fifty-five species in sixteen genera. He also briefly notices the difference in the character of the species observed in this earth, and those in another deposit from the shores of Lough Reavy, in the adjoining County of Down; the species in one indicating level pastures, surrounding the lake, while in the other they are of a sub-alpine character, and he points out the value of such enquiries to the geologist, who may, from these minute and microscopic remains, be able to argue as to the

* Comtes Rendus, January, 1849, page 135.

† Neues Jahrbuch. Leon. ünd Bronn, 1 Sept. 1849, page 56.

‡ Do. Do. Do. page 69.

§ Ann. Nat. His. Oct. Nov. Dec. 1849.

‖ Ann. Nat. His. Feb. 1850, page 121.

physical conditions of the surface in the vicinity of which the deposits have been formed.

Though not distinctly bearing on Palæontology, the researches of Mr. Edmonds, junr., on the shells found beneath the surface, and in the sand hills near Penzance, are still not without their interest to the geologist, as establishing the fact of changes in the distribution of species, occurring in such very recent periods. He finds that out of twenty-seven species, the remains of which he has discovered in abundance, there are no less than five which do not exist at present within ten or twelve miles of the locality; nearly one-fifth of the entire number, which, so far as that immediate place is concerned, may be considered extinct at present. The fact of even this local disappearance of species is important.

Again, as bearing on the laws of the present distribution of shells, a brief paper* by Captain Thomas Hutton, on some land and fresh-water shells from Affghanistan, offers some points of great interest. Among twenty-four, which he found, four are stated to be British or north European species, viz.—*Succinea putris*,
" *Pfeifferi*,
Limnea peregra,
" *truncatula*,

while some others are so closely allied, that he is inclined to think them only varieties of European species. If the identity of those mentioned be fully established, the fact is a remarkable one, for it must be remembered, that these are terrestrial and fresh-water molluscs, not marine.

We have to express regret, that the Ray Society has not, during the past year, issued any work to its subscribers.

The application of mineralogical studies to the more accurate description and examination of mineral aggregates, has engaged the attention of several geologists and chemists. To M. Delesse,† we are indebted for a memoir on a porphyritic rock with a base of felspar, which occurs in the (transition ?) group of Chagey, in the department of Haute Saone. This rock is a green porphyry, the base of which

* Jour. Asiatic Society, Bengal, July, 1849, page 649.

† Bull. de la Soc. Geol. de France, tom vi. page 383.

is a felspar, occurring in crystals, generally green, but of which the colour is often nearly as marked as that of the paste, so that the porphyritic structure of the rock is not always well characterized. On exposure, the first effect produced, is to give a red colour to the felspar, after which it kaolinizes. Its density (mean) is 2.736, and its hardness less than 6. The crystals appear to be macles, but are not well defined, the felspar belonging to the last crystalline system. Its composition was found to be—

Silica, ...	59.95	61.71
Alumina, ...	24.18	25.44
Peroxyde of Iron,......	1.05	
Protox of Manganese,	traces	traces
Lime, ...	5.65	4.79
Magnesia, ...	0.74	2.98
Soda, ...	5.39	2.74
Potash,..................	0.81	
Water,..................	2.28	2.34
	100	

Taking away the water of this felspar, we find that its composition is nearly that of *oligoclase;* but if on the contrary, we admit that water plays the part of a base in this felspar, and if it be further supposed that three atoms of water replace one of magnesia, according to M. Scheerer's ideas, the formula of this mineral would then be very nearly that of *Andesite.*

The density of the mass of the rock was found by M. Delesse to be higher than that of the contained felspar, being 2.759. The magnetic force is also high, being equal to 473 : that of steel being represented by 100.000. The loss, by heating, of the mass, was more than that of the constituent felspar. An analysis of a portion of the paste, which appeared poorest in felspar, gave the results in the second column. These analyses give, then, extreme limits between which the chemical composition of the porphyry is confined, and they show that the extent of these limits is very slight. These results are analogous to those obtained by the same author for the porphyry of Belfahy; and he considers them common to all porphyries, having as a base, a felspar of the sixth system, associated with a certain quantity of Silicate of Iron and Magnesia. He considers this porphyry as a metamorphic rock, resulting from the action on

the transition schists of a dyke of porphyry, similar in composition to that of Ternuay, which occurs near Chagey.

To the general proposition of M. Delesse, that the water which he finds in these felspars is water of combination, M. Deville objects, that the specimens examined were not transparent, and had not that purity which was essential before admitting them as a type of a new species of felspar, although he admits that the water exists. M. Durocher also objects, referring to results which he had previously obtained, in which he found that silicates, supposed anhydrous, even hyaline quartz, contain generally a 500th, or even a 50th part of water, which remains at a temperature of 100°. Felspars also contain more water in proportion as they are less transparent, are opaline or milky, or are less distinctly cleavable. He thinks that a case of diaphanous and colourless felspar, with brilliant faces, and constant angles in the crystals, is the only one which would justify a specimen being taken as the type of a new species, and supposes that in most cases the water which the felspars do contain, may be accounted for by a mixture of foreign substances, especially of hydrated silicates, analogous to zeolites. M. Durocher also thinks, that the perfect type of chemical purity cannot be met with in pyrogenous rocks, since their elements have been separated from a general magma, and have crystallized in contact one with the other. The pure minerals are met with in druses and veins; here we frequently find the summit of the crystal quite different from the base, and crystals showly forming from an aqueous solution, acquire a greater purity, than those which crystallize from a state of igneous fusion. In the latter case the reciprocal, or mutual interlacing of the crystals, show that they have crystallized nearly at the same time; and consequently the isolation of the particles of different natures could not, as M. Durocher supposes, be perfect. Experiments also proved to him, that several silicates, felspar among the number, when exposed for a long time to moist air, take up or absorb a small quantity of water, which is not parted with at 100°.

These objections have elicited from M. Delesse a general discussion of the question of the presence of water of combination in felspathic rocks. The fact of water occurring in such rocks is unquestionable; but the question is, is it in the state of combination or not? Is it cotemporary with the formation of the rock, or pos-

terior to it? If posterior, it may be either—1st, hygrometric, or 2ndly, derived from a pseudo-morphosis, or a decomposition.

The large amount, from 1 to 3.15 per cent. proves that it is not hygrometric water; nor is it water absorbed in the quarry; which would be given off, when dried. If due to a decomposition, then the loss by heat would be greater or less in proportion to the amount of the drying; but this was not the case, as the loss of the felspars was the same, with very slight variation, both before and after desiccation for many hours, in a sand-bath below 100. Felspars also, in the first stage of decomposition, or rubefaction, sometimes contain less water, but never more; when kaolinized they contain much more, but then they lose their crystalline form, and break up. The hardness and cleavage of the felspar remaining constant, show also that there has been so pseudomorphosis. Admitting, therefore, that the water is not posterior to, but cotemporary with the formation of the rock, two hypotheses still remain.

1. Is this water derived from an intimate mixture of some hydrated mineral? or

2. Is it water of combination essentially belonging to the mineral in which it is found?

The first hypothesis has been generally admitted up to the present. The water in basalts and traps has thus been generally attributed to a certain quantity of zeolite. In some cases this has been considered to be Thompsonite, in others a mixture of nepheline and mesotype, in others, different again; and thus, although basalts are remarkably constant in their aspect, the zeolite mixed with them would appear very variable. M. Delesse had already proved that the melaphyres contain not less water than the basalts;* but the best characterized melaphyres contain no zeolites at all; and where the latter do occur, they are found only in druses and cavities. The minerals, however, which occur in these druses, are quite different from those found in the paste, and their occurrence in one place by no means proves their occurrence in the other; and in reality, none of the minerals found in these druses occur in the paste, (such as quartz, chlorite, epidote, carbonate of lime, zeolites.) Again, if zeolites form a portion of the paste, when it was subjected to the action of acid, a jelly of silica would

* Annales des Mines, tom xii., 4e serie.

result, and readily, owing to the minute state of division of the silica, but this is not the case. Basalts, thus attacked, do occasionally give a jelly, but this may be from a mixture of peridote. The mere fact of a rock being attackable by acid, without leaving a jelly of silica, does not at all prove the existence of zeolites. Supposing, too, for a moment, that the water is derived from such a mixture of zeolites, and that these contain even so much as ten per cent., (as natrolite,) since the labrador-felspar of the melaphyres often has two per cent., occasionally four to five per cent. of water, there must be a mixture of one-fifth to two-fifths of zeolite. Nor is the felspar the only mineral which contains water—but the augite also. In the porphyry of Ternuay, an asparagus-green augite has 2.26 of water; or granting this hypothesis, is in other words mixed with one-fifth of zeolite, and yet these felspars and augites, have remarkably well defined cleavages, much too distinct and neat to be possible, if there were twenty to one hundred per cent. of foreign matter mixed with them. They are translucent, occasionally transparent, and have a uniform tint. Besides the felspars in the syenite of Ballon d'Alsace have 1.30 per cent. of water, and that in the granite rocks of the Vosges, and Brittany, and Normandy, nearly as much. Now, the presence of water in these felspars can be even less attributed to a mixture of zeolite in these granitoid rocks, than in the others.

Therefore, M. Delesse concludes, from the mode of occurrence of zeolites in rocks—from the absence of any siliceous jelly, when subjected to acid—and from the perfection of the crystals containing water, that it is impossible to admit that this water is derived from an admixture of any foreign substance; and that we are therefore compelled to admit that the water of felspathic rocks is water of combination peculiar to each of the minerals in which it is found.

Taking the whole series of unstratified rocks, the author finds that nearly all contain water of combination in different quantities. In granites and syenites it occurs, but in very small quantity, not more than one per cent. In porphyries, basalts, melaphyres, euphotides, &c., we have several per cent. Or taking the ordinary minerals which enter into their combination, we have for mica as much as several hundredths sometimes, but very variable. Amphibole and hypersthene contain a very small amount of water—sometimes more. Diallage sometimes three per cent. or more; augite 2.75—(the varie-

ties containing most water generally have a clear green colour.)—the felspars vary much—orthose seldom has any: never more than a few thousandth parts; while felspar, of the sixth system—saussurite, labrador, andesite, oligoclase, even albite and pericline have several per cent., the amount varying inversely with the amount of silica. The author had previously pointed out the peculiar characters of these felspars. They have a fatty lustre, and waxy fracture; cleavage is less distinct, and their density is greater than when there is no water; and they are, further, much less resistant to acids.

These memoirs of M. Delesse, on the rocks of the Vosges district, although we must express a doubt that his conclusions have been drawn from too few and too individual cases fully to justify him in drawing such general conclusions as he has from them, are extremely important as giving the results of careful analyses, not only of the mass of the rocks, but also of the constituent minerals.

The same author has undertaken, and largely carried, out a perfectly novel kind of research into the magnetic force,* (le pouvoir magnetique) of minerals and of rocks; and these researches he has extended considerably during the year. He has examined the oxydes of iron, and finds that the force of oxydulous iron ($\dot{F}e\ \dddot{F}e$) varies from 64.121 to 15.750, being greater in proportion as the crystallization is more perfect. Of titaniferous iron, $\dot{F}e\ (\dddot{F}e, \ddot{T}i)$ within even greater limits depending partly on the amount of titanium, as from 50.000 to 10.000. In chromate of iron it is much less, not being more than 136. Thus, the magnetic force in these oxydes is (all other things being equal) in proportion to the amount of the sesquioxyde of iron, it has its extreme limit in oxydulous iron, and diminishes through titaniferous iron, franklinite, chromate of iron, to spinelle and pleonaste.

Again, the same author states that the protoxyde of manganese has a force equal to 24

The red oxyde,	43
Peroxyde,	56

So that the force increases with the amount of oxygen—a paradoxical result. All the sulphurets, antimoniurets, and arseniurets, (excepting magnetic pyrites,) have a value less than 100—as also the

* Comtes Rendus, tom xxviii., page 227. Annales de Chimie, Jan. 1849, page 148.

phosphates and arseniates—in quartz it is little or none: felspar and mica also very slight. The author concludes from these researches, that as the magnet is known to have a certain influence on all bodies, as Faraday and Plücker have shown, so, that all bodies have a certain magnetic force, which, varies most materially, and in some degree with their crystalline state.

Applying the same method of research to the rocks,* the author gives the results of his examination of twenty-nine varieties of volcanic rocks, lavas, &c., of thirty-six varieties of basalts, porphyries, melaphyres, serpentines, chloritic rocks, &c.

The basaltic rocks—even those containing very little oxydulous iron—have a force two or three times greater than the mean force of modern lavas. The magnetic force of basalts ranges between 1,500 and 3,000; that of lavas between 350 and 1,500, but more generally between 600 and 900. Of serpentines the magnetic force is very variable. The amphibolic rocks have a very low force, even below 100, sometimes scarcely sensible—stratified rocks also, generally speaking, have a low force. This force does not depend on the presence or absence of oxydulous iron, but is a real physical quality, which all rocks possess in a greater or less degree; all varieties of the same rocks, no matter whence derived, agreeing very well in the magnetic force which they exhibit. M. Delesse thinks, that from such results, knowing the geological structure and constitution of a district, it would be possible to determine by calculation the deviation of the needle relatively to the meridian of that place.

As might be expected, when we remember the excitement caused by the first announcement of the discovery of considerable quantities of gold in California, and the sustained interest which the arrivals from that country have maintained, there have been, during the year, several analyses published of this gold; and the general question of its distribution and character has been discussed. M. Dufrenoy has given the results of a comparative examination of the auriferous sands of California, of New Grenada, and of the Ural Mountains. The little plates of gold from California are much larger than those from the Ural or from Brazil; and they are also distinguished by their reddish colour.

* Annales des Mines, tom xv., 4th series, page 497.

The gold sometimes adheres to white milky quartz, much rounded, and evidently having been subject to great friction; there are also schistose fragments, both of which facts shew that the original source of the gold is in granitoid schists. The general colour of the sands is black, from magnetic iron; there are besides titaniferous iron, oxyde of manganese, crystals of white zircon, (both ends perfect,) also quartz, (hyaline and smoky,) and some fragments of blue corundum. The crystalline state of the titaniferous iron and of the zircon, (which, though usually a rare mineral, is here abundant,) show that they have not travelled far.

The New Granada sands are more grey than black—they contain less iron—more zircon—the quartz is but little rolled; sometimes both extremities remain: the sand altogether is less rolled than that of California. In the Ural sands there occurs cymophane. Estimating the proportion of each of these by actual separation, there resulted for the sands from,

	California.		New Granada.	Ural.
Magnetic iron,...............	59.82		84.35	23
Titaniferous iron, Oligiste iron, and traces of Oxyde of Manganese,	16.32		15.0	50
Zircon,.........................	9.20		20.00	3
Quartz Hyaline, ...	13.70		25.0	14
Corundum, ...	0.67		7.0	Cymophane 10
Gold, ...	0.29	Various rocks,	4.65	

Though a rough approximation, this is sufficiently near. The sands of the Rhine gave very similar results with a slight variation. The author remarks on the absence of spinelle in the auriferous sands which he has found in stanniferous sands from several places; and asks, can we conclude that this mineral belongs to crystalline rocks of an earlier date than those containing gold?

M. Dufrenoy then enters on some calculations to show that the Californian gold region, even allowing the truth of the high estimates which have been made from first washings, is not much richer than the Ural, and that the discovery of gold there will not, therefore, in all probability, produce any important revolution in mining industry.

M. Rivol* has analysed several specimens of gold from California, and the mean of all his results gave—

Gold,	90.87
Silver.	8.60
Iron,	.10

Mr. Henry also, in March, 1849, gave analyses of Californian gold as below:—

Gold,	90.01	....	86.57
Silver,	9.01	....	12.58
Copper,	0.86	with traces of iron,	0.29
Iron,		....	0.54
	99.88		99.78

The specific gravity was 15.96.†

M. Teschemacher‡ also gives an analysis of Californian gold, of which the result was—

Gold, ...	90.68
Silver, ...	1.00
Oxyde of iron,	6.80
Copper, ...	0.66

The specific gravity was 16.33. If the iron, &c. be deducted, we have an alloy of gold 92., silver 7.

The question whether the gold and silver are combined in the atomic proportion has been entered upon by M. A. Levol,§ who gives numerous analyses which he had made during twenty years, without having this object in view; and from the discussion of his results, he thinks it established, that, generally speaking, gold and silver are found united in such proportions that they can be reduced to atomic formulæ, although at the same time they present themselves also in an almost endless variety of proportions.

The occurrence of gold, though in very small quantity, has also been proved,‖ in the copper mines of Chessy, (dept. de Rhone.) The ores here have, besides sulphur, iron, silica, and arsenic, some eight per cent. of zinc, and five per cent. of copper, and about $\frac{1}{10,000}$ of gold, which it is thought may be extracted profitably by the adoption of a peculiar process.

* Annales des Mines, tom xvi. page 127.

† Phil. Mag. March, 1849, page 205.

‡ Jour. Chemical Society, London, October, 1849, page 193.

§ Annales de Chemie, tom xxvii. page 311,

‖ MM. Allain et Bartenback, Comtes Rendus, tom xxix. page 153.

M. Daubree* has made some very interesting experiments on the artificial productions of minerals, adopting the same mode of research, as had already yielded such important results to Sir James Hall, Berthier, Mitscherlich, &c. He had been led to some considerations of this kind, by the study of veins of tin and titanium, and he had been convinced that fluoric acid played a very important part in the production of these veins. Besides tin, these deposits frequently contain fluo-silicates, such as mica, lepidolite, topaz; boro-silicates, as tourmaline and axinite; fluophosphates, as apatite; and the principal circumstances of the structure and composition of stanniferous veins, would be explained by supposing that vapours, containing fluoride of silica, of boron, and of phosphorus, came at a high temperature from below. To imitate this process was, therefore, M. Daubree's object; and he therefore caused two currents to pass through a porcelain tube, heated to a white heat; one of vapour of perchloride of tin, the other of vapour of water. Mutual decomposition readily took place, and the interior of the tube, towards the extremity, where the two currents entered, was covered with well formed, crystallized, and very brilliant crystals of oxyde of tin; the central and strongly heated portion had no deposit, and the other end only an amorphous deposit of oxyde of tin, which was also found abundantly in the tube of glass, united to that of porcelain. The crystals were colourless and transparent, except a few, which were brown, and they had all the adamantine lustre of natural crystals; and they differed only from the natural oxyde of tin in being colourless, having no oxyde of iron associated. In form they were right rhomboidal crystals, very flattened; while the natural crystals of oxyde of tin are derived from a right octahedron, with a square base. The oxyde of tin appears, therefore, a new case of dimorphism. This artificial oxyde of tin is also isomorphous with oxyde of titanium or Brookite; but native oxyde of tin is isomorphous with Rutile; and thus Rutile, Brookite, and Anatase, having been shown by Henry Rose, to be only titanic acid with oxyde of iron, it follows, from these experiments, that the two forms of oxyde of tin correspond with the two forms of oxyde of titanium. And this correspondence furnishes a new example of the close geometric relation

* Annales des Mines, tom xvi. page 129.

which generally unites the primitive forms of a dimorphous body, as in the case of carbonate of lime, of magnesia, &c.

The density of the natural or octahedral oxyde of tin is 6.80 to 6.96. The density of the artificial or Rhombic tin is 6.72. Similarly with Rutile and Brookite, the former has a specific gravity of 4.291; the latter of 4.128 to 4.167; so that the form of the square prism co-exists with some molecular condition, conferring a higher density than the form of the right rhombic prism.

Similar results were obtained by operating with chloride of titanium—very minute crystals of titanic acid being formed in the tube; these were two minute to measure, but appeared to be of the form of Brookite, that is of the same form as the artificial oxyde of tin. Similar results were also obtained from fluo-silicic and chloro-silicic acids, the deposits in both cases being silica, with a glassy structure and fracture: in the case of the fluo-silicic acid, it was fibrous. The crystals adhered very strongly indeed to the sides of the tube, as they do in nature to the rocks.

Having established these experimental results, the author proceeds to apply them to the explanation of his views in nature, and describing the structure and composition of veins in various countries, shows that there is a mutual interpenetration of the crystals of rutile, of fer-oligiste, and of quartz, which proves that they have been formed if not at the same moment, at least under the same conditions. This interpenetration is well known to mineralogists.

Knowing, then, that the fer-oligiste of volcanic countries is due to the decomposition of chloride of iron, by the vapour of water, a similar origin may be, he thinks, attributed to the fer-oligiste of the titaniferous veins; and that all these minerals result from the decomposition, by the vapour of water, of their respective chlorides or fluorides. The presence of fluoric combinations is supposed to confirm the supposition, such as fluor-spar, fluo-silicates, (mica) fluo-phosphates, (apatite) boro-silicates, (axinite, tourmaline.) We have beside, hydrated silicates, such as chlorite, and occasionally zeolites, tending to prove that water has had an important part to play in the filling of these titaniferous veins.

In a few exceptional cases, the fluoride of titanium has been, as it were, withdrawn from this decomposition, as in the Warwickite of New York, and the Eremite (of Dana) in Connecticut.

The author further presses the idea, that if this be the origin of such deposits, fluoric acid must have been more widely diffused, and have played a much more important part than is generally supposed. He thinks also that such experiments may tend to throw much light on the metamorphism of rocks.

In connexion with these researches of M. Daubree, we may mention an interesting paper on Arkansite, by Messrs. Damour and Descloizean. This mineral, it is known, presents an iron grey colour with a metallic lustre, similar to that of oxydulous iron. Its density is 4.030 in crystals, 4.083 in fragments. The crystals are generally dodecahedrons, with isosceles triangles, but the measurements show that they belong really to a right rhombic prism, modified.

On a careful comparison of their form, and its usual modifications, (the details of which are given) the authors were led to see that it was identical with the form of Brookite. Analysis also showed the close relation in composition. On the other hand, Brookite is well known to be totally different in external characters. It is found in very flat crystals, often small, transparent, of a red brown colour, with a vitreous fracture, and yielding a yellowish white powder, instead of cinder grey, as in Arkansite.

Now if a crystal of Brookite be placed for a few moments in the inner flame of a blow-pipe, it loses its transparency, and assumes the aspect of a little plate of iron. After this operation it has also a vitreous fracture and a metallic lustre, and its powder also becomes grey, exactly like the lustre and powder of Arkansite. The same is the result of heating it on charcoal; but it does not change its aspect when heated in a tube. These facts would all tend to prove that the crystals of Arkansite belong primarily to the species known as Brookite, but that they have been in some way subjected to a high temperature, with the disengagement of hydrogen, or bituminous vapour. Under this influence they have undergone a slight reduction, by losing a part of their oxygen, and have assumed a different external character without altering their form.

Rutile suffers the same change exactly, increasing in density. Now M. Ebelmen had already shown that titanic acid could be changed into sesqui-oxyde of titanium, by exposing it to the action

of a current of hydrogen, at a high temperature.* The author therefore concludes that Arkansite is a compound of sesqui-oxyde of titanium and of titanic acid, arising from a chemical alteration of crystals, originally belonging to the species known as Brookite.

M. Whitney, in America, had also examined the Arkansite, and found its composition as above, thus upsetting the notion of Shepard, that it was a niobate; and also stated, that it had the crystalline form and density of Brookite.†

Professor Miller, of Cambridge, also examined the crystallographic identity of the two;‡ and Rammelsberg made the same statement, and gave the details of the measurement confirming it; and he also published careful analyses of the mineral, from which he came to the conclusion, that Arkansite had the crystalline form of Brookite, and the specific gravity of Anatase; it was therefore only a variety of Brookite.§

Bearing on the same subject, is the discovery of Woèhler, that the cubic crystals found in the slags of iron furnaces, and hitherto supposed to be pure titanium, really contain cyanide and nitruret of titanium, having eighteen per cent. of nitrogen, and four per cent. of Carbon.||

M. Damour has analysed a new specimen of the rare mineral Periclase, which was first discovered and described by Professor Scacchi, of Naples. The previous analyses had given only an anhydrous magnesia and oxyde of iron, and had excited considerable doubt as to their accuracy, it being difficult to conceive how such an oxyde of magnesium, with marked alkaline properties, should exist in nature in a state of purity, in distinct crystals, and yet not decomposed. The discovery of a considerable quantity of this mineral in a block, at Monte Somma, gave M. Damour an opportunity of examining it carefully. It is found disseminated, both in small irregular grains, and in cubes and well marked octahedrons, in a mass of white

* Annales de Chimie, tom xv. 3me serie, p. 385.

† Silliman's Journal, No. 21, vol. vi. page 433.

‡ Phil. Mag. July, 1849, page 75.

§ Ueber die identitat, &c., Poggendorff's Annalen, vol. lxxvii. page 586; see also Pogg. Annalen, vol. lxxii. pages 123, 302, and vol. lxxviii. page 143 for other papers on the same subject.

|| Comtes Rendus, tom xxix. page 505, 5 Nov. 1849.

lamellar carbonate of lime. The results of two analyses are given, (the processes employed being detailed at full,) and the mean of these yield—

Magnesia, ...	93.62
Protox of Iron,......	05.99
	99.61

The specific gravity is 3.674. Is then the protoxide of iron only an accidental colouring matter, or is it essential to the crystallization of the Periclase? If the latter, the formula representing Periclase, will be—

$$24\,\dot{Mg} + \dot{Fe} \quad \text{or}$$
$$24\,(Mg + Fe) + 25\,O$$

It appears most probable that in Periclase there is native magnesia crystallized, containing a small portion of isomorphic protoxide of iron, just as in Corundum we have alumina, in quartz silica. The gangue of the periclase is a mixture of carbonates of lime and magnesia, in the proportion of four of the former, and one of the latter.*

The same chemist has re-analysed the sapphirine, and found results quite confirming those of Stromeyer who first examined this mineral. The specific gravity was a little higher, being 3.473.†

We have had two valuable communications brought before this Society, during the past session, on the analysis of minerals. Mr. William Mallet has shown by a very careful, and well described analysis of Killinite, that the specimen on which he experimented, and which appeared a good typical specimen of the Killinite, differed considerably from those previously analysed, and presented the interesting fact of containing lithia to a sensible amount, and establishing its distinctness from Spodumene. For the details of this communication, I must refer you to the journal of the Society.‡

Another was from Mr. Sullivan, on the composition of some mica, obtained from the altered rocks in junction with the granite, at Glenmalur, in the County of Wicklow.§

* Bull. de la Soc. Geol. France, 5 March, 1849.

† Bull. Soc. Geol. France, 1849, page 315.

‡ Jour. Geol. Soc. Dublin, vol. iv. page 142.

§ Jour. Geol. Soc. Dublin, vol. iv. page 155.

For the knowledge of the processes adopted in the analysis, and the detailed numerical results, the accurate description of Mr. Sullivan must be consulted; but I may notice here the interesting fact established by this examination, that the mica, which was biaxial, contained 2.506 per cent. of soda, with only traces of the oxides of Chrome, with Fluoric, Boracic, and Phosphoric acids, (the latter possibly accidental.) Mr. Sullivan discusses the mode of occurrence of these, and has promised the results of the analyses of a more extended series of micas, on which he is engaged. The total absence of lithia in that examined is also deserving of notice.

Professor Silliman has shown by analysis that the Indianite of Bournon, the matrix of the Asiatic Corundum, is chemically the same as Anorthite.*

August Stromeyer† has shown the occurrence of oxide of nickel in Serpentine and talc:—

In the bright green serpentine, (precious) of Röraas, there was	0.45 per cent.
Sundal.........	0.304
In the dirty yellow common serpentine of Röraas,............	0.32
" " Saxony,..............	0.22
In the bright green talc of Röraas,..............................	0.40
Sell,..................................	0.43
Throndjem,........................	0.23

Dr. Leeson has continued his researches on crystallography in a paper on Isormophism, and on a general simple law governing all crystalline forms, in which some new views are announced.‡

The recent statements by Malaguti, Durocher, and Sarzeaud,§ with regard to the presence of lead, copper, and silver in sea water, and of silver in organized bodies, must naturally excite attention. The water was from the sea at St. Malo, and the fuci examined from the same place; the ashes of these (*fucus serratus* and *ceramoides*,) contained $\frac{1}{100.000}$; the water only $\frac{1}{100.000.000}$ of silver; they state also that salt and all its artificial products contain silver. In the ashes of fuci they have found $\frac{18}{100.000}$ of lead, and a little copper; so that

* Silliman's Journal, Nov. 1849.

† Nyt. Magazine fur Naturvidenskaberne, Christiania, vol. vi. No. 1, 1849.

‡ Jour. Chem. Soc. of London, 1849.

§ Comtes Rendus, tom xxix. No. 26, page 780.

these metals also are concluded to exist in the medium in which these plants live.

The extreme caution requisite in such experiments, when the reagents used may possibly have been lying exposed in a laboratory used for general analysis, or have been subjected to other sources of impurity, is known to chemists; and an instance of it may be referred to in Mr. Arthur Phillips' analyses of the ashes of coal, (analyses undertaken with a view to test the truth of statements, made with regard to the occurrence of lead, and copper, in such ashes,) in which he found no traces of lead and copper, but on testing the distilled water of the laboratory found, that it darkened with sulphuretted hydrogen.*

Rammelsberg has issued a fourth supplement of his very valuable dictionary of the Chemistry of Mineralogy.† And Bischof has continued his very important contributions to the chemical and physical portion of geology, in which he discusses the history of Augite, of Diallage, Bronzite, and Hypersthene, of Augitic rock, of Olivine, and of Basalt.‡

During the year the Cavendish Society have issued two additional volumes, (two and three,) of Gmelin's Hand-book of Chemistry, a very carefully executed translation by Mr. Watts, who deserves much praise for the conscientious manner in which he has performed a task of no small labour, and has used his best efforts to bring up the information contained to the last moment.

The question of the origin and mode of formation of dolomites, has continued to engage the attention of several enquirers. Among others, Professor Favre of Geneva, has discussed the origin of the dolomites of the Tyrol,§ adopting as the basis of his hypothesis some experiments of M. Marignac. In these some carbonate of lime, and a solution of chloride of magnesium, were placed in a strong glass tube; the tube sealed hermetically, and subjected to a temperature of 200° cent. during six hours; the result was the formation of a dolomite, or a double carbonate of lime and magnesia, containing a larger proportion of magnesia than a true dolomite.

* Quar. Jour. Chemical Society, London, April, 1849, No. v. page 1.

† Handwörterbuch des, &c., Viertes supplem. Berlin, 1849.

‡ Bischof, Lehrbuch des Chem. ünd Physic. Geol. 11 band 3 heft.

§ Biblio. Univ. tom x. page 177; also Comtes Rendus, March, 1849, page 364.

Repeating the same process, but continuing the high temperature for only two hours, a limestone slightly magnesian was the result; showing that time was one circumstance important in the question. There would appear, therefore, to be requisite for the production of dolomite in this way—1st, lime; 2nd, sulphate of magnesia, and chloride of magnesium; 3rd, temperature of 200^c cent.; and 4th, a pressure equal to 15 atmospheres, or from 450 to 600 feet of sea water.

M. A. Favre, adopting these results, points out the probable concurrence of all these circumstances in the case of the dolomites in the Tyrol. There are here, however, two kinds of dolomite, one compact, the other cavernous: the former, the author supposes to have been originally deposited; the other, to be the result of alteration—an alteration, which he thinks took place almost immediately at the time of their deposit; or, as it were, a nascent metamorphosis. He supposes, further, that the fact of the connexion between the occurrence of dolomites, and the eruptive porphyries is due, not so much to any subsequent change, but to the more abundant deposit or formation of magnesian limestone around these centres, from the reactions there occurring having produced the magnesian character, while ordinary limestone was being deposited in other parts. The saccharine and crystalline dolomites he views simply as the result of the fusion of a magnesian limestone, not of any sublimation of magnesia; while the sulphate of magnesia being decomposed by the carbonate of lime, and this reaction taking place when warm, the sulphate of lime resulting would be in the anhydrous state, and thus we have an explanation of the occurrence of anhydrite.

Mr. James Bryce, junr., has given the results of careful quantitative analyses of the altered dolomites of the Island of Bute, his description of which I had the pleasure of noticing in last year's address.*

These analyses, carefully executed by Dr. R. D. Thompson, fully bear out the unexpected and interesting facts stated by Mr. Bryce, that the igneous action in the cases referred to, has driven off the magnesia from the limestone; the portion altered by the dykes, containing a much smaller proportion of magnesia than that which is unaltered.†

* Jour. Geol. Soc. Dublin, vol. iv. page 103.

† Philos. Mag. August, 1849, page 81.

Relating to the application of geological principles to practical pursuits, there have been published, during the year, some few valuable contributions.

In a detailed communication* on the iron deposits of the departments of Aveyron, of Lot, &c., M. Coquand, enters on a minute description of the general mode of occurrence and character of the beds worked. The chief supply is derived from the jurassic group, consisting of *fer hydroxide compacte,* mixed with a considerable proportion of carbonate of lime, and *fer hydroxide oolitique,* (pisolitic iron.) The latter is the most abundant, and occurs not forming beds of any great or continuous extent of surface, but small well-marked islets, as it were, in which the richness of the mineral increases towards the centre, and gradually dies away towards the edges. These are quite free from phosphorus, sulphur, and arsenic, and yield iron of the best quality. They occur in compact masses in red clays; in rognons of a variable size, with rounded surfaces; in grains, cemented by a clayey paste; and in pisolitic grains, in the cracks of the secondary rocks. Besides these, there are deposits of iron hitherto called alluvial, (but which M. Coquand has shown to be tertiary,) some of which are remarkable, as being almost entirely beds of fossils, (as *Gryphaa cymbium,*) and as containing, derived from these organisms, two to three per cent. of phosphoric acid.

The author gives a very full account of the circumstances under which these deposits are found and worked; and enters at large upon the question of the age of the beds, in which they occur, showing that they rest unconformably upon the Eocene and Miocene, and that they form the upper portoin of the tertiaries of the south-west of France; and that this position, established stratigraphically, is confirmed by the fossils found in them.

From M. Durocher, we have obtained a detailed, minute, and valuable description of the metalliferous resources of Sweden, Norway, and Finland. His memoir, which, however, offers too much detail, to be analysed here, treats fully of the position, structure, character, and origin of the several veins or beds, and of the geological constitution of the rocks and country where they occur.†

* Bull. de la Soc, Geol. de France, March, 1849, tom vi. page 328.

† Annales des Mines, tom xv. 171.

M. Riviere, has given a description of the rocks, and contained metallic veins of the Rhenish provinces, in the district included between the neighbourhoods of Coblentz and Dusseldorf, on the right bank of the Rhine.*

The country is composed almost exclusively of grauwacke rocks, with here and there some tertiary deposits, and some igneous rocks. The metals occurring in the veins, are zinc, iron, lead, copper, silver, arsenic, nickel, &c.; principally iron, zinc, copper, and lead, chiefly in the state of sulphurets, and carbonates. It is stated that there are two principal systems of these veins, varying in composition, in direction, and probably in age. Now, the cleavage of the rocks is frequently not coincident with the bedding, and it is stated that the veins of the first system, composed of quartz, blende, galena, siderose, and traces of sulphuret of copper generally accompany the cleavage, and conform to it, while the others are more independent, and cut the bedding.

After a detailed account of the works undertaken in several of these mines, and of the extent, direction, and character of the several explorations, the author passes to some general considerations on metallic veins.

All veins of blende hitherto studied, are united by general relations. They are sensibly parallel, and have a mean direction of east north-east, and west south-west. At certain points they are nearly parallel to the cleavage of the greywacke, while at others they cut this at various angles, and have inclinations different from that of the greywacke. The cleavage in many cases is different in direction from the beds, so that when the veins appear to be sometimes parallel to the cleavage, it is because they have gone in the line of least resistance, or because the secondary fractures have been determined with greater facility in the direction of this cleavage.

The veins, then, being true veins, resulting from the cracks arising out of parallel dislocations, and their general directions corresponding to that of the enclosing rocks, these fissures are probably due to the same system of dislocation which has raised the greywacke. The ribboned character of the veins seems to shew that the filling in of them was subsequent, and at successive periods.

* Bull. de la Soc. Geol. de France, tom vi. page 171.

He thinks that veins having different directions may nevertheless be of competoraneous formation, and be of the same nature; and, while not altogether maintaining it in every case, he thinks the connexion between the age of veins and their composition, worthy of much more attention than it has hitherto received: believing, that there does exist some general relation between the direction of veins, (properly so called,) the nature of the materials of which they are composed, and the epoch of their formation. He gives many instances in support of this view, and concludes by maintaining, that the older, and transition rocks, are the natural locality of metals, and that they occur, in the other rocks, principally as the result of a displacement or change of their nature, more or less complete.

Among the more curious applications of geological investigations, we would refer to the interesting enquiries of M. Boubeé, on the geological conditions of the cholera.* At the first invasion of this fearful disease in 1832, M. Boubeé had remarked that several places were severely attacked, and others escaped; and he had consequently undertaken many researches to ascertain whether this fact had any connexion with the geological nature of the soil, &c., being the more induced to consider this, by observing, that in many countries where endemic diseases prevailed, the limits of the area over which they spread, are frequently marked out by the limits of the geological formations, so that each geological formation constitutes, as it were, a natural locality for peculiar morbid affections, such that the medical constitution of a country depends in some way on its geological and topographical constitution. He points out the remarkable influence which the nature of the soil has on the absorbent powers, and dryness of the ground—on the coldness or heat—on the nature of the gases evolved; and further, the nature and amount of the mineral or organic matter taken up by the waters used for drinking, cooking, &c. And referring to the cases of goitre, confined chiefly, as we pointed out last year, to countries where the waters used contain magnesia—to the greater prevalence of pulmonary pthisis in countries where the soil is calcareous—he states that the cholera has shown itself with much greater virulence in those countries which are occupied by easily disintegrated rocks, and in general terms, by

* Bull. de la Soc. Geol. de France, tom. vi. page 540.

tertiary or alluvial deposits, extending itself with less intensity in countries where the older and harder rocks exist.

In confirmation of this idea, numerous localities are referred to by the author, and the circumstances appear fully to support his hypothesis.

In fact this case is only one out of many which might be quoted as evidencing the importance of an accurate knowledge of the structure of any district, before determining on the measures desirable to be adopted for its drainage, improvement, &c., if already inhabited; or in the case of new countries, before determining on the locality and site of town or settlements.

Bearing on some of the most important questions in physical geology, we have had two short, but valuable papers, from Mr. Hennessy,* during the year. In one, "on the changes of the earth's figure and climate, resulting from forces acting at its surface," the author has pointed out how inexplicable the observed phenomena of the earth's figure, and of the variation of gravity at its surface would be on the hypothesis of the earth's primitive solidity; and in the subsequent one, "on the variation of gravity at the earth's surface," he further shows, that this hypothesis entirely fails to explain the secular refrigeration of the earth's surface, its observed ellipticity, and the variation of gravity.

Mr. Hennessy has also communicated to the Royal Irish Academy, (Proceedings vol. iv. page 333,) a valuable paper, "on the influence of the earth's figure, on the distribution of land and water, at its surface;" and a second part of his researches in physical geology to the Royal Society of London.

All these papers forming portions of the same general researches, I regret that the details of the latter have not yet been published; and I must, therefore, omit any general notice of the author's results, as it would be obviously unfair to enter upon such an examination with the data now before us. Among the geological results, however, which Mr. Hennessy thinks to be established by his investigations, we may mention one or two—that the stability of the axis of rotation of the earth will progressively increase, as solidification advances—that the thickness of the earth's crust cannot

* Jour. Geol. Soc. Dublin, vol. iv. pages 139 and 147.

be less than eighteen, or more than six hundred miles, (a result very different from that announced by other investigators;) and also with reference to the directions of great lines of elevations, depending on the action of the pressures of the shell, and nucleus at their surfaces of contact, that inasmuch as observation as yet has not proved the existence of a zone of mean pressure, the directions of these lines of elevation must be comparatively arbitrary.

We trust that Mr. Hennessy will continue these very important researches, and extend their application to the explanation of geological phenomena.

I alluded last year to the promised "Manual of Scientific Enquiry," intended to be published by the Board of Admiralty, for the use and benefit of the officers of the naval service. This work has since appeared, under the able superintendence of Sir John Herschel; and in addition to the subjects more immediately interesting to the geologist, (and which are ably treated by Mr. Darwin, in a valuable and very suggestive paper on geology, Mr. Mallet, our late President, on earthquake phenomena—a paper characterized by the ingenuity and simplicity of the processes recommended for observers, Sir Henry De la Beche, on mineralogy,) we have short papers on tides and tidal observations, terrestrial magnetism, hydrography, astronomy, zoology, botany, &c., which together furnish an amount of information regarding the principal points deserving of observation, and the best methods of observing, that cannot fail to contribute largely to the progress of knowledge.

The connexion also of physical geography, with geological structure, is daily becoming more acknowledged and insisted upon; and the republication, in an improved form, and in an English translation, of Humboldt's "Aspects of nature," may be regarded as one of the evidences of this. We have also had a translation of Guyot's lectures, entitled, "The Earth and Man," and containing some original and eloquently expressed views.

The constant recurrence in foreign works, in the accounts of travellers, or in the descriptions of geographers, of very different and very various standards of measure, for the notation of vertical heights, must have been a frequent source of annoyance to every student. Thus, elevations will be found stated in English, in Paris,

or Berlin feet—in metres, &c. &c., so that long, and sometimes troublesome calculations are required before any comparative results can be obtained. The desirability of some general standard being adopted, is, therefore, too obvious to be questioned; and it is with great pleasure we would direct your attention to a valuable communication by Miss Colthurst, presented to the Royal Geographical Society by Mr. Greenough, in which she has adopted and carried out this idea of a common standard, to which the measures of different countries can be reduced. The standard assumed by Miss Colthurst is the geographical mile taken at the equator; this being a fixed quantity universally known, and dependant upon the figure of the earth itself. By dividing each of these miles into one hundred parts, each part is equal to 60¾ English feet; and taking five miles, or five hundred of these degrees or divisions, Miss Colthurst has constructed a scale from which, by simple inspection, the relative values of any elevations expressed in English, French, Bavarian, Danish, Swedish, Dutch, Spanish, Austrian, or Prussian feet, or Roman or Portuguese Palms, can be ascertained, as well as their value in the natural scale, adopted as the common standard.

It only now remains to apply a similar process to depths below, as well as to elevations above, the same level; and a general, simple, uniform, and philosophical term will be had as the standard to which all vertical distances shall be referred; the advantages resulting from which would be so great, that its general adoption is much to be desired.

The application of physical observations of another kind to geological research has been pointed out by M. Daubree,* who has reduced his long continued observations on the temperature of springs in the valley of the Rhine, at various heights above the sea, and springing from various rocks. He states as among his results, that springs at the same altitude have nearly the same temperature—that the decrease of temperature corresponding to elevations is not uniform—that the excess of temperature above that of the air increases with the elevation as it does with the latitude—and that all those springs which have a mean temperature more than 2° cent., above that of the place whence they arise, are from faults, or lines

* Annales des Mines, tom. xv. 4e serie, page 459.

of dislocation. The author, from these facts, is led to think, that the thermometer would form to the geologist, as it does to the mariner, a most useful instrument, in deciding the presence or absence of any fault in this way.

I have thus, gentlemen, very briefly, and very imperfectly laid before you a sketch of some of the most important communications brought forward during the past year, tending to advance the progress of our study. It would be impossible within the limits of an address to give even the slightest outline of all that has been done. The literature of geology so rapidly increases, that I cannot pretend to have even the time or the opportunity, busily engaged as I am, of becoming acquainted with such publications, much less the ability of laying clearly before you their contents. It would, besides, be but idle presumption in me to lay claim to such acquaintance with the numerous subjects which tend to illustrate our widely extended science, as would enable me to apprehend their full value, and succinctly to extract it for your information. I trust I have, however, been able to indicate a few of the more important subjects on which the attention of geologists has been fixed during the year; to shew some, at least, of the additions which have been made to our knowledge, and thus, to satisfy you that geologists have not been idle; that geology has not halted in its advancing progress; and that deeply as we have drank at the well of truth, its sources are still unexhausted and inexhaustible. And I shall, in however slight a degree, still certainly, have contributed to such progress, if I have been enabled to indicate, at the same time, any of those points on which additional evidence or illustration may be derived from Irish geology, and have thus stirred up to emulation in the race some of those I now see around me.

But, before concluding, I must crave permission, warmly and heartily to express my sincerely felt obligations for the high honour conferred on me, by the appointment to preside over you, and more especially at a period so critical in the history of the Society. That it was so, has made me regret that you were not guided by some one of more experience, and having more leisure at his disposal; while at the same time, the difficulties of the post only rendered the selection to fill it the more honourable.

But, gentlemen, its duties never could have been discharged without the cordial and kindly support and aid I have received from each and every member of your Council and Officers, and of the Society. The same partiality which led to my selection, has favourably acknowleged my weak efforts for your benefit, and overlooked my deficiencies; and the heavy debt of gratitude, which I had already incurred during my intercourse of many years with the Society, has been only increased by the more marked kindness, (if such were possible,) I have experienced as your President. It is also a great gratification to me, that by your allowing me to resume my former position as Secretary, in which I feel that my services can be of more advantage to your Society, you have given me another proof that my efforts, however feeble, have been received with kindness, and that my willingness and anxiety to promote your interest is not doubted, whatever my ability to accomplish those wishes may be.

It is now, gentlemen, my duty to resign this chair to Colonel Portlock, whose name is essentially connected with the progress of Irish geology—a well known and long tried friend to the Society—and under whose able guidance we cannot fail to advance. With this conviction, gentlemen, of the advantage which must accrue to the Society from the change, the duty of resigning would always be a pleasant one; but it is to myself a source of peculiar pleasure, when I find in the successor you have elected, him under whom I myself first used the hammer; my former master, my former and my present friend, to whose kindness I have been much indebted, and to serve under whom again, will recall some of the fresher enjoyments of my earlier years.

March 13th, 1850.—"On the rocks in the vicinity of Balbriggan Co. of Dublin;" by PROFESSOR OLDHAM, F.R.S. Secretary of the Society.

IN this communication, the author described in detail the mineral character and geological relations of the rocks extending from Skerries, northward, beyond Balbriggan, pointing out the succession observed, the disturbances and alterations produced by the intrusion of igneous rocks, and the fossiliferous nature of some of the series. The occurrence of these fossils was first made known by the geological survey, in connexion with which the results will be published in detail.

April 10th, 1850.—"On the Inequalities of the Sea Bottom, during the Tertiary Epoch," by LIEUTENANT-COLONEL PORTLOCK, R.E., F.R.S.

THE most striking characteristics of modern geology are its rigid adherence to facts, and its appeal to natural and speculative causes. It is thus that we are led from the present to the past, by a chain of inductive reasoning, and that we compare the doubtful of the past with the certain of the present time, rather than, by reversing this rational process, endeavour to build up a theory of the past, and then to bend the present into a conformity with it. Proceeding upon this truly philosophic principle, I may observe, that nothing is better known than the great inequality of the sea bottom, and that more especially in bays and river estuaries. The presence of sand bars, and of mud banks, the deep water of channel courses, though bounded by shallows, and the frequent variation of such channels, either by the silting up of one channel, or the scooping out of another, need little comment or illustration. These inequalities, and their variations, due to the varying forces, (either in amount or direction) of the marine currents, which are the great agents in the distribution of detritic matter, are not confined to our present ocean; and it is my principal object, therefore, to exhibit them in the sea bottom of the epoch antecedent to the existing one—namely, the tertiary. The tertiary strata of England are principally known from the great basins of London and Hampshire, and the most re-

markable division of them has acquired the name of London clay. As my present object is not so much the description of geological peculiarities, as the exhibition of physical phenomena connected with these strata, I shall simply observe, that the identity of character of the London clay, and the plastic clay under it, both in the London and in the Hampshire, is most remarkable. The one is, in both localities, a blackish blue, and the other a brownish red clay, and hand specimens, taken from both localities, cannot be distinguished from each other. In like manner, there is a similar interstratification of sandy strata, so that these basins have, like that of Paris, been found to be, and used as reservoirs of water. The London clay is much less broken up by sand beds than the plastic clay, and the water obtained by filtration, through those beds, is usually so impure, from the presence of mineral matter in solution, that it can rarely be applied to domestic purposes. The water obtained, on the contrary, either from the sand beds interstratified with the plastic clay, or from the surface of the chalk underlying it, is pure, and therefore palatable. The numerous artesian borings, both in the basins of London and Paris, have made these facts well known, but as yet no distinct chart of the borings, exhibiting the varying depths of the strata, has been published, although there can be little doubt that it would be a most interesting document. Taking advantage of the similar relations of the strata in the Hampshire basin, borings for water have, though more rarely, been made; and the application of the principles on which they are made, for public purpose, brought the matter under my notice at Portsmouth, and specially drew my attention to the great variation in depth of the respective strata. Some years ago, an artesian well was formed in the victualling yard, near Gosport, and an abundant spring was met at the depth of three hundred and twelve feet. In this section, a yellow clay was at the surface, and a remarkable bed of clean sand, thirty-one feet thick, occurred at forty feet from the surface; at ninety-four feet a small spring occurred in a bed of sand, two feet thick, and at one hundred and nineteen feet commenced firm homogeneous clay, the first bed being eighty-seven feet, and the second one hundred feet thick, a bed of shelly sand, three feet thick, separating them. In the borings, an occasional hard stone was met with, but little else to disturb the uniformity of the deposit.

I have no means of testing the exact nature of the deposits of this boring, but I am inclined to think that the loose clays and gravel near the surface, were post tertiary, and that the two great beds constituted the mass of the London clay. With this section before us, and the knowledge that another artesian boring, at Haslar hospital, had been also successful, it was proposed to obtain water for the Block-house Fort, about one mile and a quarter from the Clarence yard, by an artesian well. In this section, eighty feet consist principally of gravel, corresponding to the shingle beach of the present sea, and only broken by a little sand and silt, a small bed of oysters (the recent species) occurring at the depth of fifty feet. The London clay now commenced, and was here divided into three great beds, the two first separated by sixteen feet of dark sand, which yielded bad water, the upper bed being about fifty-eight feet, and the second sixty-eight feet thick. The lower bed was forty-six feet thick, and separated from the one above it by a bed of sand, eight feet thick, which, however, yielded no water, and was probably, therefore, entirely enclosed by clay. The lower bed was occasionally also sandy, and when passed through a bed of clean sand, twenty-four feet thick was met with, and a supply of good water. The borings here, therefore, were successful at three hundred and ten feet, or nearly at the same depth as in the Clarence well, though in the distribution and character of the strata passed through, there were many striking variations. In the Haslar well the water was obtained at a somewhat less depth, but I am not aware of the nature of the successive beds.

The position of the Block-house well, as compared to that of the Clarence, was in the direction of the dip of the underlying chalk, and the uniformity of depth at which the water was found, seemed to exhibit a tolerably level bottom, at the time of the deposition of the sand bed which produced it, although the variations of the subsequent beds indicated considerable modifications in the course of their deposition. The general deduction, however, seemed to be a fair presumption, that a boring proposed to be made in one of the basins at Portsea, and nearly in the line of strike of the chalk from the Clarence well, should yield water at about the same depth, the distance being about two miles and a-half ; and it was determined by the Board of Ordnance to apply the money voted for a tank to another artesian well.

At the surface no shingle appeared, but after passing through a little superficial clay and sand, the London clay was entered, and the borings continued in it for a depth of more than five hundred feet; when the plastic clay appeared, a few inches of hard sand, yielding no water, and therefore isolated or enveloped in the clays alone separating them. This clay continued, without any intercalated sand beds, being one uniform mass, to the depth of six hundred and ten feet, when the borings entered the chalk, and water rose in the bore-hole to about three feet from the surface. In this boring, therefore, all the sand beds had disappeared, and the two great deposits of clay were found almost in immediate contact, shutting out thereby the supplies of water. It will be observed that, in this locality, both the London and plastic clays had acquired an unusual development, and though such an accumulation may have been partly aided by local depressions in the surface of the underlying chalk, the consequence either of wear or of faults, it is manifest that the continued deposit of clay, during the whole of the plastic and London clay epochs, requires some other explanation. It is, indeed, highly probable that several causes have co-operated to produce the effect. For example, whilst a depression in the chalk may have led to the unusually deep deposits of the plastic mud, the sands may have formed a beach or bank, whilst the deep channel continued to have a mud bottom, and that this channel was subsequently silted up in the London clay epoch—and, finally, that the London clay covered over the sand, and formed a shallow basin. Doubtless, as shown by other partial sand beds, there were frequent variations in the currents and silting up forces; but such were only consistent with what is still observed in this and every other bay, subject at once to deposition from a river, and to tidal action; and, in like manner, the varying depths of the several deposits are in conformity with the existing inequalities of the sea bottom. I shall only, in conclusion, repeat the observation, that a careful investigation and tabulation of the results of borings, would throw a most important light on the condition of the sea bottom at successive epochs.

Lieutenant-Colonel Portlock communicated to the Society a letter he had received from his relative, Mr. Richard Rubidge, now re-

siding as a medical practitioner in the Cape country. The object of Mr. Rubidge is to describe a remarkable district, consisting of sandstone, marl, and shale, which is bounded on the north by the Zeurberg range of quartzose and porphyritic rocks, and on the east by similar rocks. These strata appear to have been deposited in a bay, are but little disturbed, and are about eight hundred feet thick.

Fossil wood is found in considerable abundance, and sometimes of great size, Mr. Rubidge having measured one tree, thirty-six feet in length, and two feet in diameter. Near the Sunday River vegetable impressions are also abundant; the fossils are not, however, limited to this class.

As Mr. Rubidge found in part of the deposit several genera of marine molluscs, and as the genera trigonia, gryphœa, &c., occurred amongst them, he considers himself justified in referring the deposits to the lias, or, at least, to a portion of the oolitic series.

The fossils will be brought before the society, in a more detailed manner, by Lieutenant-Colonel Portlock, in a future communication.

Mr. Rubidge further states that, on the faces of the Lias Cliffs, and in the gullies worn by the torrents, he found the bones of small rodent insectivora, and birds in great quantities. The skulls of the rodents he considers very remarkable, as they are too large for a mouse or rat, and he is not aware of any existing South African animal to which he can refer them. Many of the bones do belong to mice, rats, bats, &c., but it is very difficult to account for their existence in such vast quantities, since they are not broken, as would be the case, had the animals to which they belonged been brought to these places, and there devoured by birds of prey. In one spot, a gully in the alluvial soil, between the Sunday and Bushman's Rivers, the accumulation has been so great that bushels of bones may be collected, the largest of which belonged to animals larger, indeed, than a rat, though still of very moderate size. Mr. Rubidge speaks of an intended visit to the coal formation, near Shilih, which is in the land lately taken from the Kafirs, and the Society may therefore, ere long, expect another communication of much interest.

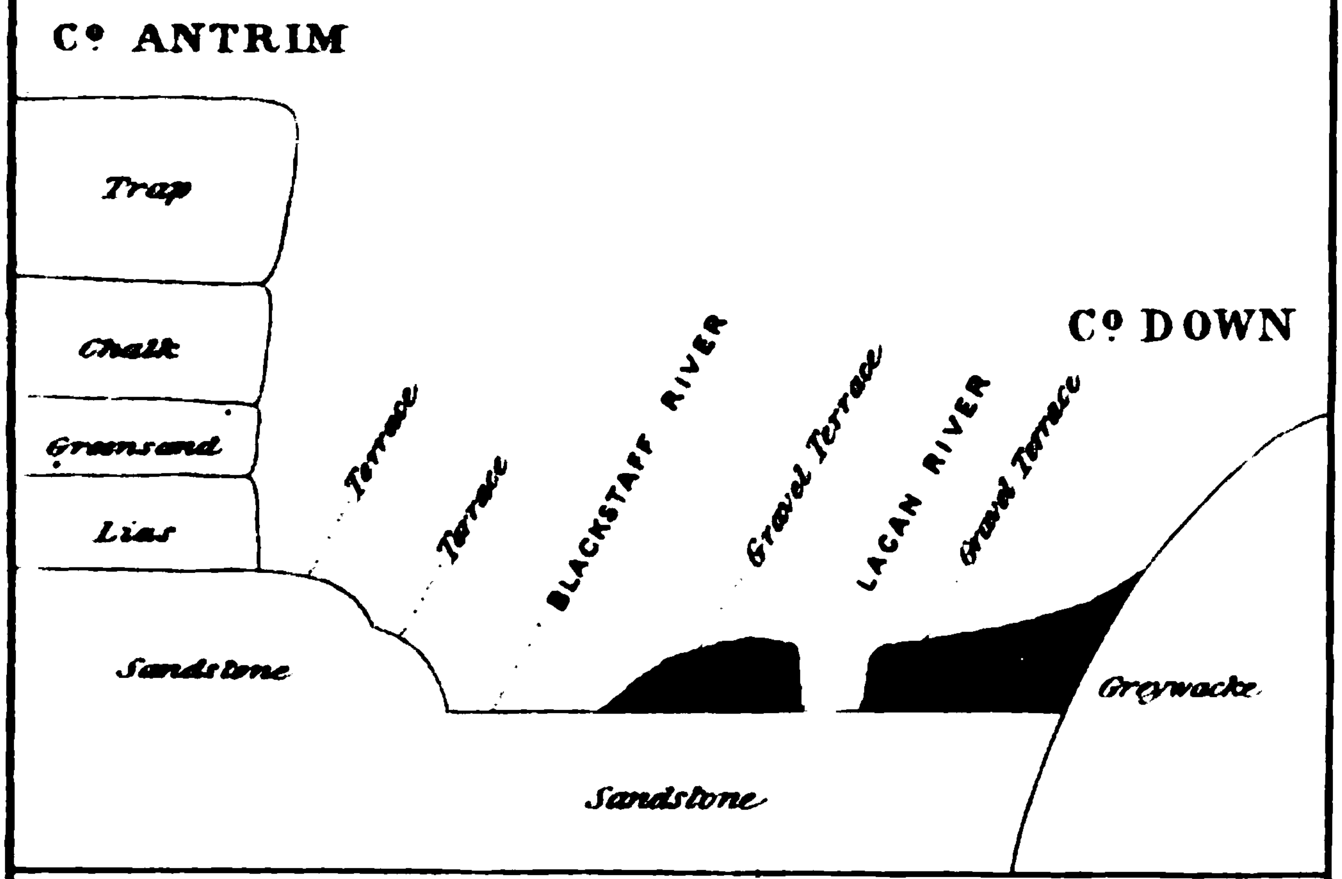
May 8th, 1850.—"Observations on the neighbourhood of Belfast, with a description of the cuttings on the Belfast and County Down Railway;" by James Mac Adam, Esq. F.G.S., Queen's College, Belfast.

The Belfast and County Down Railway runs from Belfast Lough to Strangford Lough. During the time of its construction, I took frequent opportunities of examining the cuttings; and having discovered some phenomena that were worthy of investigation, I was led to extend my examination for a short distance into the neighbouring country, confining my observations almost entirely to the post tertiary formations.

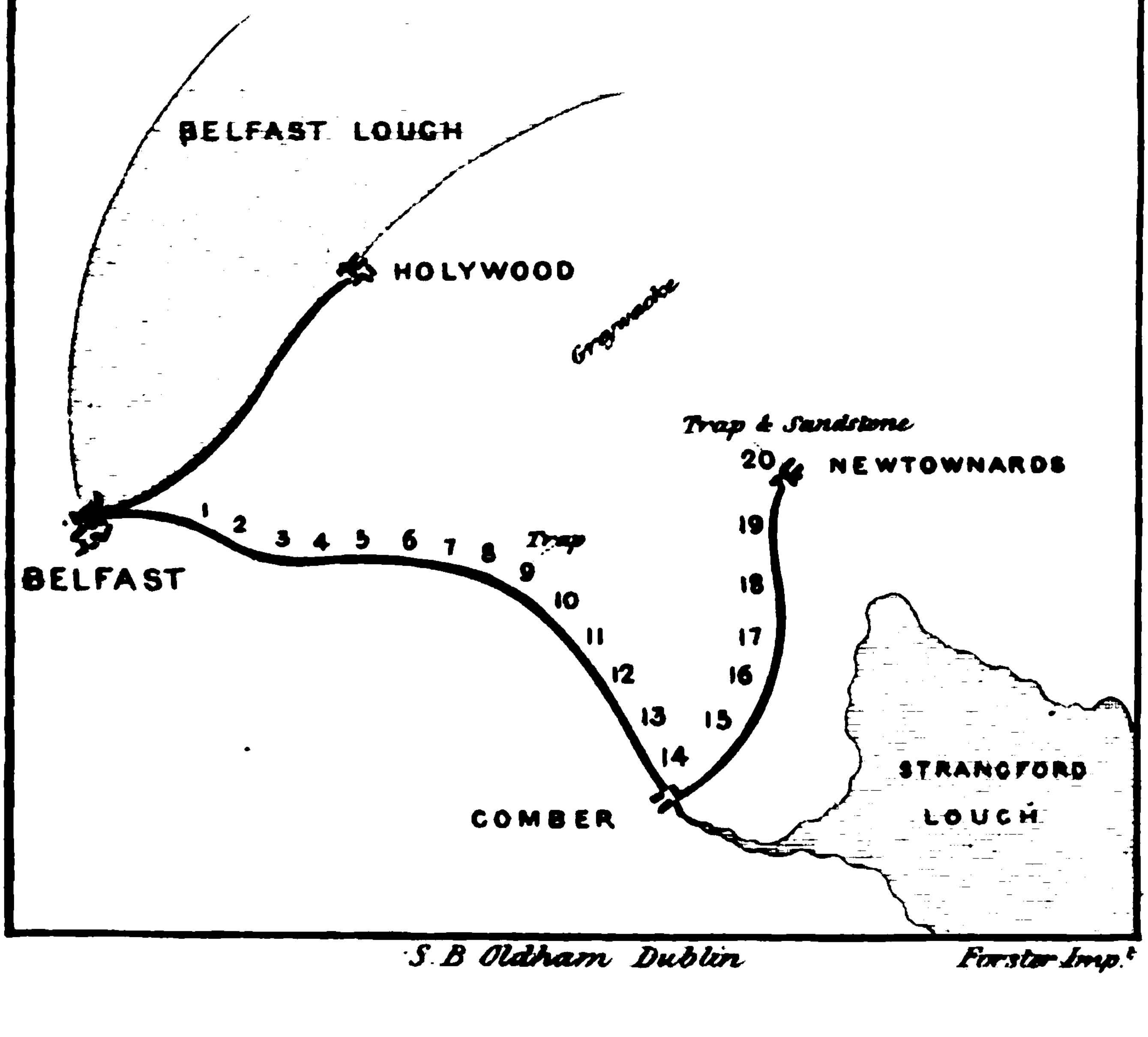
Referring to the map of this part of Ireland, we observe that the town of Belfast is situated at the extremity of Belfast Lough, which sheet of water is placed between the Counties of Antrim and Down, being not only, politically, a division between them, but, physically, a separation of two geological districts, each offering distinct features and phenomena. That of Antrim, on its north side, presents formations of trap, chalk, and other secondary rocks, which frequently exhibit steeply escarped fronts; that of Down, on the south, is composed of greywacke, having in a few places the edges of the lower secondary rocks resting upon it, but never showing those escarpments which are so remarkable in the district opposite, and which impart such a magnificent character to the scenery of the Antrim coast. The rock underlying the bed of the Lough is sandstone. (See plate.)

Proceeding from Belfast Lough into the interior of the country, we find the separation of these two geological districts continued in the valley of the Lagan. This valley extends from near Moira to Belfast, having on each side the same geological formations, and in the same order as they occur at the extremities of the Lough. The river Lagan finds its way into this valley between Dromore and Moira, having taken its rise in the greywacke district of Down. Its breadth is very insignificant, but its length must be considerable, as it has a serpentine course. It empties itself into Belfast Lough close to the town, and is there a tidal river, the tide flowing up it to some distance, and causing a difference in its body of water at different times of the twenty-four hours. Very extensive new quays are just now completed on both sides, which confine the river within their boundaries, whereas formerly at high tide there was a great

SECTION ACROSS THE VALLEY OF THE LAGAN OR BELFAST LOUGH.



BELFAST & C.o DOWN RAILWAY.



space at the end of the bay next the town covered with water, and at low tide, on the contrary, there was a disagreeable landscape of mud banks, that rendered the neighbourhood very displeasing to the eye. A spectator on the neighbouring hills could observe the river wending its circuitous way through these mud banks at low water; at high tide it required very skilful pilotage to bring vessels up to the town, without running them aground; but the improvements at the mouth of the Lagan, that have been recently effected, have produced a great change. A straight channel has been cut for the river, so that vessels drawing ten feet at low water, and eighteen feet at high water, can reach the town with the greatest ease. The mud banks, which have been in a great measure reclaimed, are now useful dry land, and are becoming gradually covered with buildings. The Lagan brings down a quantity of alluvial matter, which is deposited in the bends of its course, particularly near its mouth. This may be well observed at the Queen's Bridge, or as it is commonly termed, the Long Bridge of Belfast, where an alluvial flat may be seen at both sides of the river. On the County Down side, the tract occupied by the suburb called Ballymacarrett, has been plainly formed from the deposit from the Lagan, mixed with silt. This tract is bounded on the east by a small river, called Con's Water, immediately above which is a terrace of gravel and sand, running on towards the south-west, and proceeding up the right bank of the river Lagan. On the Antrim side, a similar tract of alluvion extends to the Botanic Garden, where there is the commencement of another terrace, similar to the one opposite, and extending inland for a considerable distance; so that in this part of its course, the river Lagan flows between the two gravel ridges or terraces. (See plate 1.)

There are several smaller rivers that flow through the ground on which Belfast is built. The chief of these is the Blackstaff, to which I wish more particularly to direct attention, although generally a very insignificant stream, except in time of great rains, when it overflows its banks to a considerable extent, and to the great annoyance of the neighbourhood. It empties itself into the Lagan; its original embouchure, some time in the last century, was altered, and a straight cut was made for it, which alteration has only served to make the river little better than a nuisance, and latterly much complained of, as producing unhealthy exhalations. This river has evi-

dently been much larger at one time than at present, as in examining the ground on each side of it, the bed of a former river is plainly discernible, the present one being a mere thread of water in dry seasons, that has cut its path deeper in the original bottom; but in wet seasons, when the water in it accumulates, the expanse on each side will give some idea of what the river once was; it has evidently been a great drainer of the surrounding country, bringing in its waters a quantity of mud, which being deposited upon silt and sand at its mouth, has, in all probability, contributed to form a great part of the tract on which Belfast is built. In digging in the streets and foundations of that town, silt and sand are constantly met with—very often beds of shells, all of living species, and marine peat.

Since the Blackstaff has diminished in size, the depositions of mud from it have manifestly diminished also, and the increase about the town has been latterly due to the Lagan, although all the small rivers have been observed to furnish their quota of the general mass. It is curious likewise to observe the effect produced by an increase of population. The small rivers bring down greater quantities of animal and vegetable matter, and the more mixed with mud, as the neighbourhood becomes the more inhabited. Within the last half century there has been a great increase of alluvial deposit upon the sands of the bay near Belfast, partly from this cause, and partly from the planting of a great number of trees on the north side of the Lough, which have sheltered the sea wrack, that had been previously blown to a distance. This wrack is the means of retaining the fine muddy particles, and thus forming new land. The straight cut, before mentioned, that was lately made for the river Lagan, has caused the reclaiming of several of the mud banks, and excavations have been made in them in connexion with the harbour improvements. These excavations exposed to view many beds of shells, all of recent species.

The deposition of mud on the County Antrim side has been more rapidly transformed into dry land, owing to the sea being kept out by the embankments of the Belfast and Ballymena Railway, which runs on that side of the bay. Bearing in mind, that it was the sheltered sea wrack that contributed so much to the formation of this mud deposit, and looking up at the trees that composed the shelter, we perceive that they are planted upon a ridge or terrace of

a very marked character, rising near the shore, frequently with a steep face, to fifty or sixty feet above the present sea level, then rising gradually inland, attaining a breadth of more than a mile, and ending at the mountain side. A part of the road from Belfast to Antrim passes over it at different levels. Its substratum is sandstone, covered with clay, through which local gravel is sparingly distributed, with occasionally marine shells of existing species. It may be traced from Carrickfergus to Belfast; but near the latter it is more escarped, as may be well observed from the low road along the bay. It continues into the higher parts of Belfast, having upon it the Barracks, the old Poor-House, and a long line of streets. Near the old Poor-House, and in many other places, its junction with the low ground can be well observed. The market-place called Smithfield, lies immediately at the bottom of the terrace; and in this place, where West-street opens into it, some trunks of old trees were found in an excavation for foundations. They were lying in sand similar to sea sand, about five feet under the present surface. With these trees were also found shells, principally littorina and cardium. There was silt beneath the sand, and similar beds of silt and sand, frequently with large quantities of shells, are found in this low ground, at the same level everywhere throughout the town. Continuing our way, however, upon the terrace, rising thus above Smithfield, we pass into the Falls suburb, where many factories have been built upon it, and going onwards, we see its breadth well displayed at Springfield, and its escarped front very prominent at the Lunatic Asylum, and in various other places up the valley to a considerable distance inland. The clay upon the surface of this terrace is of variable thickness; we may in different places in its escarpment, where the surface clay is thin, perceive the sandstone cropping out under it, being a portion of the same sandstone, already mentioned, as occupying the bed of Belfast Lough. Through this sandstone many whyndykes are observed to pass, almost all in parallel directions, nearly north and south. (See plate 1.)

The river Blackstaff flows in a hollow at the base of this terrace, which is thus placed at the north or left side of the stream. On the right, or south side, another terrace rises, composed of gravel and sand, which extends also up the valley. This is the terrace mentioned already, as commencing near the Lagan at the Botanic Gardens. It

is of considerable breadth, having, on the side next the Blackstaff, the Union Work-house, the Deaf and Dumb Institution, and various other buildings erected upon it, and proceeding for a considerable way up the valley, opposite to the former ridge. To an observer on the neighbouring hills, this gravel ridge or terrace appears to divide the valley into two parts, in one of which the river Lagan flows, and in the other the Blackstaff—the former flowing between two gravel ridges, the latter having a gravel ridge on its right side, and a clay and sandstone terrace on its left. The ground at the bottom of these terraces of the Blackstaff is wet boggy meadow, often covered with water, and having a substratum that has plainly been a deposit from a river flowing into an estuary.

The gravel terrace that occurs on the right, or County Down side of the Lagan, has already been alluded to. It may be traced for a considerable way up the valley, as the other terraces; or rather, if we follow it coming down the river, we see it well developed, especially near the river's mouth, not far from the bridges; and it continues, preserving its character, to some distance below Holywood, where it becomes broken, from the intrusion of greywacke rocks. As stated before, it runs behind the alluvial tract on the County Down side of the Lagan. Immediately above Con's Water we can see it to great advantage at the first cutting of the County Down Railway, where it has a breadth of more than a mile, and proceeding along the upper road to Hollywood, its tolerably even surface, with but little undulation, is quite conspicuous. It rests against, or hangs upon, the greywacke hills that form the back ground; and the line of junction of the terrace with the hill can in many places be determined by the difference in the vegetation—that upon the gravel being much the richer. Viewed from the low road near the shore, it exhibits in many places an escarped front, as may be instanced at Richmond Lodge and Knocknagoney; and from this road, crossing the terrace at two places—at Bunker's Hill and at the entrance of the town of Holywood—we have an opportunity of observing from these points the ridge sloping down in a steep talus to the low ground. The gravel that composes it is much mixed with sand, which frequently becomes so abundant, as to cause the soil to be almost wholly composed of it; and where the surface of the terrace is uneven, some of the elevations are sand hills, like downs. The

sand in these hills is ferruginous, quartzose, and is much used for economic purposes. It may be seen in large quantity at the first and second cuttings of the County Down Railway, at Mount Pottinger, where the terrace comes near the upper bridge, and at Newton Breda, near the Church, where there are some curious sand hills surrounding a hollow that must have once contained water. In continuing our course along this ridge of gravel, farther up the valley, we find upon it numbers of small hills like tufts, locally termed Drumlins, composed of sand or gravel, or a mixture of both. If we cross the river Lagan again, to the County Antrim side, we find the same characters in the ridge upon that side of the river—a continuous ridge, with similar hills or Drumlins upon it. These hills have been already mentioned to this Society by our fellow-member, Mr. Bryce, in a paper published in the first volume of the Journal. That gentleman has alluded to the kind of gravel found in the Drumlins. This is, in a great measure, local gravel, consisting of trap, chalk, flint, sandstone, greywacke, quartz, green sand, mica slate, granite, and quartz rock. Of these materials, trap is the most abundant, chalk and flint very frequent, sandstone less common, perhaps from its friable nature, and green sand but rare, likely from the same cause; the greywacke and quartz increase in quantity as the gravel is nearer the County Down hills. Mr. Bryce has supposed the primary boulders to have been brought by a current from the north-west; and in his paper referred to, he has advocated this opinion, by arguments deduced from an examination of the drift generally over this part of Ireland. We may also start the hypothesis of a current from the north-east, as these primary boulders have some resemblance to rocks existing in Cantire in Scotland, and the opening of Belfast Lough is in the direction of that district. There may also be traced on the shores of the channel between Ireland and Scotland, the effects of former great currents in that direction. At all events they have come somewhere from the north, as the effects of a current to the south are everywhere visible. On ascending the County Down hills, above the grand terrace, we find the drift upon them to be chiefly greywacke and quartz, derived from the local rocks; but mixed with this are pieces of trap, chalk, and flint, that are found up to the very summits, an elevation above six hundred feet, which fact has been already mentioned in Mr. Bryce's paper.

Between Belfast and Comber there is a valley running about north and south, in which a branch of the County Down Railway is placed. The hills on each side of this valley are of greywacke, but the greater part of the middle of it is occupied by an immense deposit of gravel, rising often on the sides of the hills to an elevation of more than two hundred feet. There are many small knolls consisting of gravel mixed with sand, on each side of the railway; and the soil of the fields, towards the lowest part of the valley, is half composed of stones of various sizes, so as to present a curious appearance when newly ploughed. This gravel has the same composition as that already mentioned. Among it are many beds of sand, but not very pure. At Comber, the railway takes an easterly direction to Newtonards, going still through a gravel formation, the majority of the gravel hills adjoining being upon the north side. They become less frequent towards the south, on approaching Strangford Lough. Near Newtonards there is a change in the geological structure of the district. At the hill of Scrabo there is a very large development of sandstone, the age of which has not yet been exactly determined; and capping this sandstone is trap rock. On the flanks of this hill the superficial covering is sandy clay mixed with boulders, such as we observed before; but at this place there is much less of the sand and gravel, like that of the adjoining country. Some of the trap boulders are very large, and have evidently been derived from the summit rock of Scrabo.

The Belfast and County Down Railway consists of two branches —one to Holywood, a length of four miles, on the south side of Belfast Lough; the other to Newtonards, on Strangford Lough, going round by Comber, a distance of thirteen miles. The Belfast terminus is near the Queen's Bridge, and is erected upon ground that was till lately covered at high water, but has been reclaimed by the recent harbour improvements. The Holywood branch runs upon an embankment placed upon this alluvion. Within the last fifty years, there was a sandy strand between Belfast and Hollywood, that was sufficiently hard to be used as a road; but the increase of alluvion upon it gradually rendered it unfit to be travelled on. This branch terminates at Hollywood in a gravel formation, called the Kinnegar, which occupies a space of tolerably even ground, about three-quarters of a mile long, and one-quarter of a mile broad.

From its being used as a common, its peculiar features can be well studied. Its elevation above the low water mark is from ten to twenty feet; and it must have had formerly a greater extent, as its edges next the sea bear the marks of having been acted on by the waves, that are still gradually wearing it away. This low ground formation extends for a short distance along the bay to the eastward, having the lower part of the town of Hollywood built upon it. The gravel composing it contains the same materials as the Drumlins of the valley. There are also in it considerable beds of recent shells. (See plate 1.)

The branch to Newtonards starts from the same terminus at Belfast as the other, and runs along an embankment over the alluvion as far as Con's Water, immediately above which, it reaches the gravel terrace at Turf Lodge, where the first cutting occurs. I shall describe briefly the cuttings in order, calling this one No. 1. It is almost wholly in sand, having some veins of clay through it, with small quantities of fine gravel, such as we find upon the sandy part of the shore of the bay. A few fragments of shells were obtained from it, and its elevation above low water is between eighty and ninety feet.

No. 2 cutting is an almost pure sand, in which an increased number of shells were found.

No 3. Sand mixed with clay, having a few shells.

No. 4 is a shallow cutting through the extremity of a Drumlin. In it were several alternate layers of sand and small gravel, such as occur so commonly on sea beaches. The elevation is as before, between eighty and ninety feet. The gravel preserves the same character as mentioned above, there are many fragments of Antrim trap, chalk, and flint, mixed with the local drift of greywacke and quartz, and with some pieces of sandstone and granite.

No. 5 has much sand, having in it some markings, such as are produced by worms on a sandy shore. At the north end the sand is overlaid by a bed of sandy clay, containing much large gravel, and the two beds have a well marked line of demarcation between them. At the south end, on the contrary, a waving bed of sand is placed upon the clay. Broken shells were also found in this cutting.

No. 6 shows sand much mixed with clay, containing the same kind of gravel as the rest. At the north end a bed of clay containing

boulders, overlies a considerable quantity of sand, in which is minute size gravel, like what is frequently met with at Holywood; there is more clay at the south end. Through a part of this cut, red clay overlies what is locally termed blue-till, which would indicate a considerable thickness of clay at this place; and this cutting would seem to have been made not a regular gravel hill, but rather in a projection in the underlying clay, which might have been an island when the adjacent country was covered with water, before the deposition of the sand and gravel.

No. 7 and No. 8 contain a large quantity of sand.

No. 9 shows a variation from the other cuttings. Under a thick coat of overlying gravel, mixed with sand and clay, we observe a mass of trap rock, which is occasionally faintly columnar, of a very compact texture, not zeolitic, but containing much felspar; in it may be often observed crystals of glassy felspar. It is not unlike a trap that occurs in the Co. Antrim, at Carnmoney Hill, four miles from Belfast, and like it, containing chalcedony, and a black mineral supposed to be chlorophœite. This was one of the most important cuttings on the line. At the south end where it was commenced, was a quarry called Graham's quarry, which had been previously wrought for this trap, its quality as a building stone having been much esteemed. The quarry was filled up in consequence of the railway embankment, but previously the trap had been worked to some depth; its bottom, or lower surface having been reached in some places, it was found to rest on greywacke, exhibiting a junction rarely to be met with. The greywacke had a compact texture; but the most extraordinary circumstance brought to light, was the existence of marks upon it, resembling the ripple marks on sandstones, a phenomenon of very rare occurrence in a rock so old as greywacke. Some of the trap in this cutting had a ferruginous seam in it like iron ore, which, on examination, was found to be merely a superficial streak. In the insterstices of the trap that was faintly columnar, there was found occasionally a substance, sometimes whitish, sometimes grayish, apparently caused by infiltration, and which is a very common occurrence in similar rocks. The superficial covering over this trap was not very thick, sometimes clay, sometimes sand mixed with the usual gravel; the clay may have been partly derived from decomposed trap.

Nos. 10, 11, 12, 13, are through gravel mixed with sand, and do not present any remarkable features.

No. 14. Under the surface is gravel, having in it some boulders, mostly trap, of a tolerably large size, and underlying this are sand and sandy clay. At the south end, the sand is very compact, resembling a loose sandstone. In this cutting were found recent shells and rolled lias fossils, in a tough blue clay, eighteen feet under the surface.

No. 15 has gravel as usual: a few shells were got here. From a hill near this, consisting of sand and fine gravel, some shells were also obtained.

No. 16 has in addition to the sand and gravel a number of trap boulders. I observed also among the gravel some pieces like variegated sandstone. In the lower part of the cutting is sand, which appears to go beneath the rails.

No. 17. Gravel and sands.

No. 18. The same. At the east end there is a thick stratum of gravel, like a beach, over sandy clay. I saw in it also a loose sand or compact sandstone. I got fragments of shells, chiefly oysters.

The country to the northward of these last cuttings has numerous gravel hills; to the south it slopes down towards Strangford Lough.

No 19 has the upper part through superficial clay, with the usual drift, among which are some large boulders, chiefly trap. At the west end, the soft sandstone may be observed; the east end has a close resemblance to a beach, having a layer of coarse gravel overlying sand mixed with gravel. At the west end the gravelly sand is of a dirty yellow colour, as if derived from disintegrated trap. I obtained some shells in this cut.

In the last three cuttings I observed an increase of greywacke and quartz gravel. We now approach the mountain of Scrabo, composed of trap, overlying a great mass of sandstone, which is much quarried for economic purposes.

No. 20 is an interesting cutting; it is in a dirty, red, loose sandstone, sometimes a little variegated, and showing bands of different shades, as if deposited under a sea, near the shore. There are through it a number of little flatted roundish masses of the same substance; the beds seem to be nearly horizontal, except near a whyndyke which crosses the railway, and which has changed the dip of the sand-

stone immediately adjacent, and also the colour of this adjacent sandstone to dark colour, with increased hardness, like some primary slates. Over the sandstone there is a very thick bed of boulder clay.

Shortly after passing this cutting, we arrive at the end of this branch of the railway, at the Newtonards terminus.

Although the examination of these railway cuttings, from their being mostly in gravel and sandhills, may not be interesting to the general observer, it is so to the geologist, as he obtains proofs of the sea having stood at a higher level than at present, and of its having been spread over the surrounding country. The disposition of the sand and gravel, as exhibited in the cuttings, is precisely what we every day witness upon a sea beach, where we find both regular and irregular layers of the like, according to circumstances. The small quantity of shells, and their frequent broken state, point out that a large quantity of drifted materials has been transported, by some cause or other, and that, in its passage, many shells must have been crushed to powder, so that few could be expected to have remained entire. The composition of the drift also demonstrates that a large portion of it has been derived from the north, and has become mixed with local debris. Sandstone was passed through between Comber and Newtonards, but in cutting No. 20, that rock was displayed to the best advantage, it being at the base of the hill of Scrabo. The summit of this hill is composed of trap, resembling that obtained in cutting No. 9, and in the thick bed of clay that covers its slope down to the railway, there are many trap boulders, evidently derived from the summit rock. No. 9 and No. 20 were the only cuttings in which rock was the chief material worked through, the others being made in transported gravel, sand, and clay, a loose sandstone occurring in some places under the roadway, in the line between Comber and Newtonards.

Having now given a description of the physical and geological features of this district, I am desirous of inquiring into the probable causes of such a deposition of gravel and sand as exists in the valley of the Lagan, the valley between Belfast and Comber, and the country about Strangford Lough. From the great uniformity of the composition of the gravel, it may be concluded that it was deposited under the same conditions, and also that the configuration of the

rocky part of the district was nearly the same as at present. This gravel was also partly derived from rocks, situated towards the north, and currents from that direction, or it might have happened that, according to the views of some geologists, icebergs drifting from the north may have brought the gravel with them, and left it at a distance from its present source. Be the cause what it may, it is evident that, in each particular locality, gravel has been rubbed off the rocks of the place by the action of water, in a liquid or solid state, at a former period, and that this has been mixed with other gravel derived from the north.

If we look at the long extent of mineral precipices presented by the east coast of Antrim, displaying, in many places, faces cut down almost perpendicularly, and that plainly indicate a greater lateral extension at former periods, we must conclude that this operation has been effected by some cause, not as yet traced out. If we go along the north side of Belfast Lough, we see a line of similar mural escarpments, terminating in the same abrupt manner, and which must have been formed in the same way as the others along the east coast, and which escarpments must have formerly extended farther to the south. A portion of those rocks has, consequently, been reduced to fragments, some remaining at the base of their mother precipices, but the greater quantity carried to the south, or, perhaps, a part to the east, outside the entrance of Belfast Lough. This lough, or the space occupied by it, must, at one time, have been partly filled with these fragments of trap, chalk, flint, and sandstone, as we now find them, and it is to this circumstance that I wish more particularly to direct attention.

If the water stood at a height seven hundred feet above the present sea level, it would have covered the hills on the County Down side of Belfast Lough. It is not necessary to conceive that there was so much additional depth of water; it was, perhaps, comparatively shallow. We have proofs that there have been accumulations of fragments of the Antrim rocks spread over the bottom of the lough to a great thickness, which must be consequently subtracted from the total height of the water. This accumulation of debris must have attained a height of six hundred feet, so that there might not have been upon it a greater body of water than is at present found in the lough. I have stated that fragments of An-

trim rocks are found in the County Down, at an elevation of above six hundred feet, and this is perfectly compatible with the hypothesis, that the mass of fragments at one time attained that thickness. In the progress of time the water wore its channel deeper, and, consequently, fell in level; the tops of the hills would thus become dry, with the gravel upon them, as we now see it. As time rolled on, the water would continue deepening its channel, and would become narrower. Suppose it fell to about two hundred feet above present low sea level, a margin of gravel would remain on each side, like old shores, and this exactly is what I have described as occurring on both sides of the lough, the gravel terrace at that elevation, on the Down side, corresponding with the clay terrace on the Antrim side. The water going down still lower, might possibly, by a slow descent, cause the margins to be less steep, and, consequently, produce a gentle slope, which we can observe on both sides, for some distance; but, again, coming down to about seventy feet above present low water, the marked escarped terrace, on each shore of the bay, indicates a further lowering of the water, and proceeding still downwards, we have the Kinnegar, at Holywood, generally about twelve feet above the low tide, plainly a portion of a large gravel mass that extended far into the lough, corresponding with which, in level, are a raised beach, to the east of Carrickfergus, and likely part of the ground on which Belfast is built.

The same reasoning may be applied to the appearances of the gravel formation between Belfast and Comber. The water must have partly covered the greywacke hills, which would appear as so many islands, when the water descended in level; and which water, wearing its way deeper, in the progress of time, would eventually leave the valley dry, as it now is, having found a lower bed in Strangford and Belfast Loughs. The occurrence of shells, in the railway cuttings, as well as in the neighbouring hills of the gravel formation, and the arrangement of sand and gravel, precisely like what is seen upon a sea beach, which many of their cuttings display to us, all testify that there is no necessity for calling in the aid of a violent catastrophe to account for present appearances. When a simple cause can explain, we need not apply to one that is complicated or recondite.

The valley of the Lagan would present the same conditions as

Belfast Lough. The two gravel ridges, through which the Lagan now flows, are evidently portions of one and the same terrace, and this terrace is the continuation of the one that we have traced along the County Down side of the lough, where it is on the same horizon with the clay formation of the opposite side. These gravel and clay terraces preserve the same relations to each other, as we proceed up the valley, so that, according to our hypothesis, the entire valley of the Lagan, along with the Belfast Lough, has been filled with gravel and clay, and covered with water comparatively shallow, which, gradually descending in level, has left its marks behind, in the appearances which I have described. (Plate 1.)

A work has been recently published by Mr. Robert Chambers of Edinburgh, entitled, "Ancient Sea Margins," in which he has recorded a great number of observations, principally made in the British Islands, for the purpose of ascertaining the different levels at which masses, generally of gravel, and for the most part arranged as terraces, have been found to occur. These deposits are not confined to the neighbourhood of the sea, but have been discovered in valleys and plains in the interior of the country. In many of the deposits shells have been found, in a great measure resembling those inhabiting the actual neighbouring seas. Mr. Chambers concluded from these observations, that the physical configuration of this portion of Europe was, at one period, very different from what it now is, and that also at that period the state of the animal world was not very different from what it is at present. There was a large extent, occupied by a sea, containing a number of moderately sized islands, and subsequently to the formation of these gravel deposits, either the land has been upraised, or the sea lowered in level, so as to present the actual extent of dry land. Mr. Chambers has noted and tabulated, with great care, the different heights at which these deposits occur, and by a comparison of a great number of observations, he has come to the conclusion, that there has been a perfectly equable shift of level from the higher to the lower elevations, and that there is no indication of any convulsive or fitful movement having taken place.

Without, in any way, binding myself to adopt Mr. Chambers's opinions, I must testify to the diligence with which he has followed out the investigation of this subject, and the service he has rendered

to science, by directing to it so particularly the attention of the physical geographer. From the district which I have described in this paper, he could have drawn many illustrations of his theory, as there are distinct proofs that the sea has, at different periods, stood in it at different levels; but whether this was the case with the entire mass of oceanic waters over the globe, or merely with an isolated portion of them, I consider that we are unable as yet to pronounce with any degree of certainty; we must compare the results of the inquiries of observers in different localities, before any general conclusion can be adopted. I am still inclined to adhere to the opinion, that it is not required to suppose that there was an upraising of the land, to account for the present position of the gravel and sand formations which I have described; their present place can be explained upon the theory, that the sea, which once covered them, has worn in them a channel for itself, is now found at a lower level, and has thus left them dry, as we now see them. The theory of elevation may be applied to mountain chains, and to explain the actual position of many of the hard, rocky masses of our planet, but if a simple cause is sufficient to account for some of the more recent phenomena, we must urge its adoption in the true spirit of philosophising.

The opinion that the sea was, at one period, shallower than now, and that it was widely spread over the surface of the globe, at a higher elevation, has been brought forward by several geologists, who have also pointed out that it has worn channels for itself, and that it has descended to a lower level, and, in many places, has become deeper, from its alteration of the superficial configuration of the crust of the globe. As bearing upon this point, I shall quote the following extract from the "Berichte uber die Mittheilungen von Freunden der Naturwissenschaften in Wien." 1846, p. 114:—

"M. Streffleur considers that an explanation may be given of the general and gradual lowering of the level of the sea, without having recourse to a diminution of the general mass of water, or to an elevation of the land. A diminution of the mass of water, by chemical means, is possible, and not improbable. But if we have recourse to mechanical means, we must then seek for a mechanical cause to account for the sinking of the sea, in a gradual manner, and with the quantity of water remaining constant. The rotation of the earth traces the furrows of currents at the bottom of the sea, and the bottom will become excavated in the deepest parts of these furrows, and between two currents an embankment or ridge is produced. The

particles of solid matter that are separated by the action of the water, in the bed of the current, are precipitated upon this intermediate ridge, and which increases in this manner until it reaches the surface of the water; in the meantime the bed of the current is continually becoming deeper. For so far the surface of the sea has not become, in any great degree, lowered; but as the daily tides bring solid matter to the embankments that are now beginning to rise above the sea level, and as these banks become wider, the sea begins to sink in those places where the loose materials have been heaped up by the currents. The ebb no longer brings back what the flood had thrown upon the solid matter above the level of the sea, and these embankments eventually become high and dry. It consequently happens that the waters, which were formerly shallower, and which covered a greater extent of the earth's surface than they do at the present time, have, in consequence of its rotation, become separated into portions of various extent, and that the general result has been higher continents, and deeper and narrower seas."

As large quantities of gravel occur in many parts of Ireland, at different heights above the present sea level, observers have many opportunities of examining for further proofs of the opinions mentioned in this paper. It is only by the comparison of a great number of observations that their truth or falsehood can be tested, and in this state I leave the subject to rest upon its merits.

In the supplement to this paper there will be found more particular details respecting the shells obtained in the gravels and sands of the district described.

"Supplementary observations on the neighbourhood of Belfast;" by JAMES MACADAM, ESQ. F.G.S. Read June 12th, 1850.

IN order to render more complete the detail of my observations upon the recent formations in the neighbourhood of Belfast, I have made out lists of the shells that have been collected in different places, and at different levels.

The greater part of the town of Belfast, as was stated in my paper read upon the 8th May to this Society, is built on a flat consisting of sand and silt, with frequent beds of shells. These shells are of the same species as those found in the cuttings in the sand and mud banks, that were carried on during the progress of the harbour improvements. I made a large collection at different times; but not being satisfied with the variety of species which it afforded, I applied to Mr. John Grainger, a member of the Belfast Natural History Society, who had also made a very large collection, and during the time that the cuttings were most exposed, so that he

had opportunities of obtaining most of the varieties. From that gentleman I obtained the greater number of the following names. It is to be recollected that all these shells were found at or under low water mark, so that in point of level, they are to be regarded as the lowest deposit, and also the newest in regard to time; although in respect to geological age, I conceive there is no difference in those obtained at the various levels, *or at most very little.*

The following is a list of the shells found in the silt and sand of the Harbour of Belfast, and in the foundations of the town:—

Murex erinaceus,
Aporrhais pes pelicani,
Natica glaucina,
Nucula margaritacea
oblonga,
Trochus cinereus,
magus,
Patella vulgata,
Littorina tenebrosa,
neritoidea,
Lacuna crassior,
Purpura lapillus,
Cypræa europæa,
Rissoa ulvae?
Odostomia pallidula,
Scalaria Turtoni,
Cerithium reticulatum,
Nassa reticulata,
macula,
Buccinum undatum
var. carinatum,
Fusus antiquus,
Creusia verruca,
Pholas candida,
crispata,
dactylus,
Balanus, (two species,)
Vermilia,
Serpula,
Teredo norvegica,
Lucina radula,
flexuosa,
Artemis undata,
tincta,
Amphidesma Boysii,
compressum,
Anomia ephippium,
Ostrea edulis,
var. parasitica,
Pecten maximus,
opercularis,
varius,
Mytilus edulis,
Modiola tulipa,
Saxicava rugosa,
Syndosmya alba,
Pullastra decussata,
Lutraria elliptica,
oblonga,
Scrobicularia piperata,
Corbula nucleus,
Mya truncata,
arenaria,
Thracia convexa,
pubescens,
phaseolana,
Psammobia ferroensis,
vespertina,
Solen marginata,
pellucida.
Cardium echinatum,
edule,
exiguum,
Mactra subtruncata,
elliptica,
Venus laminosa,
aurea,
Tellina solidula,
tenuis,
depressa,
Montacuta purpurea.

The next locality for recent shells, ascending in level, is the Kinnegar at Holywood, which contains several beds of shells from fifteen to twenty feet in elevation. These are of the same species with those just mentioned, but the variety is not so great; however the specimens obtained were generally larger and finer than those got from the cuttings in the harbour.

The terrace behind Holywood, and which runs along the south side of Belfast Lough, and then inland, up the valley of the Lagan, preserves an average level of about eighty feet. I obtained shells from it at Knocknagoney, Richmond Lodge, Bunker's Hill, and Ballagh's farm, all of which places overlook Belfast Lough. The species were not numerous, but the same as in the deposit below—Ostrea, Cardium, Mytilus, Littorina, Tellina, Mactra, Pullastra, Pecten, Rissoa. They were often broken. I found similar shells in the continuation of the terrace up the valley; but their occurrence is more rare, as there are not many excavations in that part of the terrace, where they are elsewhere most generally to be found, and they are not likely to be got in the Drumlins, which have been opened in many places. I procured several at Milltown, a short way off Shaw's Bridge, and in some other excavations, caused by a new road in that neighbourhood.

I stated in my paper of 8th May, that the gravel formation of the terrace is found also in the valley between Belfast and Comber, in which the Newtonards branch of the County Down railway runs. At about the same elevation as above, I found shells in some of the railway cuttings, the species becoming still fewer—Ostrea, Pecten, Mytilus, Cardium, Mactra, Buccinum, Littorina, Trochus, Purpura, Turritella; and in the gravel on the north side of the railway, in its course from Comber to Newtonards, I found a few of these species also. I may again mention the rolled lias fossils obtained from the railway cutting at Comber; they were Gryphaea incurva, and Pachyodon Listeri, evidently brought by some current from the County of Antrim, and I observed that in this cutting several of the recent shells were also rolled.

At the same elevation on the terrace of the County Antrim side, I obtained several shells. I got a considerable number in an excavation at a villa called the Grove—Cardium, Tellina, Ostrea, Mactra, Nassa, Patella, Littorina, Cerithium, and some others in fragments,

of the species in the list mentioned above. I also got fragments at Fort William and Parkmount, and expect that future excavations will discover other localities.

Ascending in elevation to what may be considered a higher terrace, (or perhaps more correctly, the higher part of a gently sloping gravel ridge, that rises from the terrace already mentioned, so that we may regard both as the same formation,) we find on the County Down side, near the Knock, and not far from No. 3 cutting of the County Down Railway, a bed of clay in a small river, apparently overlying variegated marl, and having over it a bed of gravel and sand. In the clay I found Fusus bamfius, Nucula oblonga, and another Nucula, the species not determined, with a few fragments of other shells. The elevation of this bed is about one hundred and fifty feet, and it is a very remarkable occurrence, being quite different from the other formations in which shells were obtained. I shewed the clay and shells to Mr. Hyndman of Belfast, who, along with Mr. Bryce, had published in 1842, an account of a deposit of shells found in the excavation for the Belfast Water Works, on the Antrim side of the Bay, at an elevation of about one hundred feet; and that gentleman at once recognised the perfect similarity of the two deposits and their contents, although situated more than three miles apart. The stratification at each place was also the same; and it is to be recollected, that variegated marl is of very rare occurrence in the County of Down. Messrs. Hyndman and Bryce's paper was copied into Portlock's Report of the County of Londonderry, p. 738.

I found fragments of shells at the Stye Brae, in Gilnahirk, the highest part of the gravel formation, at about two hundred feet. This place is about a mile from the Knock, and at it the gentle slope of the gravel terrace commences, from whence it joins the adjoining greywacke hill, and its course towards the bay can be seen to the greatest advantage.

The above is what I wish to add to my observations in the paper of the 8th May. My researches in the shell localities must necessarily be very incomplete, as my attention was not directed to them until I had examined the County Down railway cuttings. I have no doubt that future operations in the neighbourhood will bring to light other phenomena of the same character, and highly deserving the consideration of the geologist.

"On a Tabular View of the Order of Deposition, and Geological Succession of the Groups of Stratified Rocks;" by Captain R. Smith.

Captain R. Smith exhibited and explained the construction and objects of a Tabular View of the Stratified Rocks, which he had constructed, designed to indicate at a glance the chronological succession, the mineral character, and the prevailing fossils of each subdivision, together with the localities where it is best seen, or most easily studied.

June 12th, 1850.—"On the Minerals of the Auriferous Districts of Wicklow;" by William Mallet, Esq.

The circumstances attending the original discovery of native gold in the beds of some of the streams of the County of Wicklow, have been already often detailed, and will therefore need but a brief repetition. The source of the auriferous streams is the mountain Croghan Kinshela, whose summit forms a portion of the boundary between the counties of Wicklow and Wexford. The stream from which most of the gold has been obtained rises on the north-east side of this mountain, and flowing down one of the glens with which that part of the country is intersected in almost every direction, joins the Aughrim river, a little above the confluence of the latter stream with the Avonmore. It receives several smaller streams at different parts of its course, in all of which, *some* gold appears to have been found, though in general in such small quantity as not to repay the cost of its extraction. Small pieces of the precious metal had been accidentally found by individuals, at various times preceding the year 1795, in which year great numbers of the peasantry, excited by the account of some large pieces which had been casually discovered, began to search for gold, though in a very unskilful and desultory manner. About six weeks afterwards, the government

took possession of the stream, and stationed a detachment of militia on the banks to keep away the peasantry. The latter had, however, obtained about eight hundred ounces of gold during the short period they continued at work. The government then took the washings into their own hands, and continued the search for about six years, not confining themselves merely to washing the alluvial matter constituting the bed of the stream, but also driving a level into the side of the mountain in search of the vein in which the gold was supposed to be imbedded. These trials, however, proved unproductive, and the expense exceeding the value of the gold obtained, government abandoned the workings in 1803, since which time a few of the peasants of the country round, have occupied themselves irregularly and at intervals, in rewashing the sand which had been carelessly turned over before, and from which they still obtain some gold in small grains, but scarcely sufficient to afford them the means of subsistence. About six or seven years ago, some further attempts in search of gold were made by a company organized for the purpose, by cutting extensive trenches at right angles to the course of the Ballinvally stream. These, however were, also unsuccessful, and the washing is again solely carried on by a small number of the peasants.

Although this part of the country, since it has been known to be auriferous, has been an object of some attraction to mineralogists, but little attention seems to have been directed to the other minerals which are to be found accompanying the gold in the alluvial deposits. These, however, are interesting, not only from their number and variety, but also from the occurrence amongst them of some of the rarer species, which have not, I believe, been noticed in any other locality in Ireland. The following minerals were obtained from a considerable mass of sand and gravel taken from various parts of the bed of the principal stream, and examined by passing it through sieves of different degrees of coarseness, separating the minerals of different specific gravity by washing, and finally examining each portion carefully with the aid of a lens, and picking out the individuals of different species with a forceps. I have also subjected to analysis a few of the minerals whose composition appeared interesting to determine. The following list comprises all the species which I have been able to detect, but probably does not by any

means exhaust the number of those which actually exist in the sand:—*

Gold,	Galena,
Platina,	Sulphuret of Molybdenum,
Tinstone,	Sapphire,
Magnetic Oxide of Iron,	Topaz,
Micaceous Iron,	Zircon,
Red Iron Ochre,	Garnet, (2 varieties,)
Hydrous peroxide of Iron,	Quartz,
Common Clay Ironstone,	Prase,
Iron Pyrites,	Augite,
Titaniferous Iron,	Chlorite,
Wolfram,	Felspar,
Oxide of Manganese,	Mica.
Copper Pyrites,	

Gold.—This mineral occurs here in probably its most beautiful form. It possesses the true golden yellow colour and metallic lustre which characterise the metal, and, owing to the attrition to which it has been subjected, generally presents a beautifully brilliant surface. It occurs in grains of all sizes, from the smallest spangle up to a mass weighing twenty-two ounces, the largest hitherto found. The specific gravity of some small grains I found to be 16.342. The analysis of these grains gave

Gold,	92.32
Silver,	6.17
Iron,	.78
	99.27

This is equivalent (neglecting the iron) to $8\frac{1}{4}$ atoms of gold and 1 of silver.

Platina.—Mixed with the gold are some very small flattened grains of a white colour and metallic lustre, which, as far as their minute size permitted me to examine them, appear to present all the characters of platina. They are infusible before the blowpipe, and insoluble in nitric acid, but dissolve in aqua-regia. Their

* I have since observed, in addition to those here mentioned, Arsenical Iron, in small fragments, and also Spinelle. The latter occurs, in very small grains, along with the second variety of garnet, from which it is readily distinguished by its peculiar purplish-red colour.

occurrence intermixed with the gold when all other minerals have been washed off, is a proof of their high specific gravity.

TINSTONE.—The occurrence of this mineral in the sand is mentioned by Weaver in his reports on the gold stream-works, but he does not seem to have been at all aware of the large quantities in which it exists. From the comparatively small portion* of sand which I had an opportunity of examining, I obtained about 3½ pounds of stream tin, a portion of which being reduced, yielded an ingot, which, when refined by a second fusion, is hardly inferior to the finest grain tin.† Should this mineral be found in the mass of the sand in a quantity at all approaching that in which it existed in the specimen from which this was obtained, it would probably richly repay the labour and expense of its collection and smelting. From the small quantity in which other minerals of high specific gravity exist in the sand, and the constant supply of water, very little difficulty would be experienced in separating it from the rest of the sand, and the almost total absence of arsenic and lead would render it extremely easy to obtain from it metallic tin of the very first quality. The mineral itself occurs in grains varying in size from fine sand up to pebbles of half an inch in diameter, and for the most part of a dark brown colour, with some fragments of various tints of yellow and red; some presenting the peculiar appearance to which the name "wood tin" has been given. All these varieties are slightly translucent, some of them highly so. Many of them present distinct traces of their original crystalline form; the principal varieties observable being the primitive obtuse octohedron, the same with a short four-sided prism interposed between the two pyramids, and the latter of these with various truncations of its angles and edges. The specific gravity of some picked crystals was 6.753. A careful analysis of this tinstone gave, as its constituents—

Peroxide Tin,	95.26
Peroxide Iron,	2.41
Silica,	.84
	98.51

* The exact weight of the specimen examined I do not know, but I think it certainly did not exceed 150lbs.

† The specimen smelted in this experiment yielded about 61 per cent. of tin, but more would be obtained on the great scale, as in this case no pains were taken to extract the tin remaining in the scoriæ.

I believe that it also contains a minute trace of columbic acid, but of this I am not quite certain.

MAGNETIC OXIDE OF IRON is found in the state of fine sand along with the gold and other heavy minerals, when the lighter portion of the sand has been removed by washing. It does not, however, here constitute such an important constituent as it does in the greater auriferous deposits, as those of California and the Oural,* but exists in comparatively small quantity.

MICACEOUS IRON.—This mineral occurs in very large quantity, both in the bed of the stream, and in the alluvial deposits which form the banks on either side. In the latter it is sometimes found in very large rolled masses, and in the state of pebbles of various sizes it constitutes a considerable portion of the auriferous gravel and sand. It consists of extremely minute plates, which, under the microscope, sometimes exhibit the form of six-sided tables. It is of a steel gray colour, yielding a red powder similar to that from ordinary red hæmatite. Its specific gravity, determined in the ordinary way, was 4.486, but this is probably rather lower than the truth, owing to the difficulty of entirely removing air bubbles from the surface of the mineral when immersed in water. A very pure specimen yielded, on analysis,

Peroxide Iron,	95.72
Silica,	1.84
Alumina,	.98
Oxide of Manganese,	.49
	99.03

RED IRON OCHRE.—This mineral is found massive in small pebbles of a bright brick-red colour externally, and dark brownish red fracture. It is very soft, and soils strongly like red chalk. In other respects it resembles the micaceous iron.

HYDROUS PEROXIDE OF IRON occurs in large quantity in the form of small cubes slightly rounded on the edges, and obviously derived from the decomposition of iron pyrites. Exposed to the blow-pipe flame in a closed glass tube, they decrepitate, and give

* Vid M. Dufrénoy. "Etude comparative des sables aurifèrès de la Californie, de la Nouvelle-Grenade et de l' Oural." Annal. des Mines, 1849. IVe livraison, p. 3.

off a good deal of water, and the residue in the tube appears to consist of almost perfectly pure peroxide of iron.

Common Clay Ironstone is also found in the sand, but in small quantity. It differs in no respect from ordinary brownish clay ironstone, except in containing rather a large proportion of oxide of Manganese, the exact amount of which, however, was not determined.

Iron Pyrites.—This mineral occurs in the form of small cubes, extensively diffused both in the pebbles of clay-slate, which constitute the largest portion of the auriferous sand, and in the rocks from which these pebbles have been derived.

Titaniferous Iron.—There are some small pebbles to be found amongst the sand, hardly to be distinguished by external appearance from the clay ironstone before mentioned, but of much higher specific gravity, varying from 4.3 to 4.4. These contain a large portion of titanic acid. I have not, however, made an exact analysis of them.

Wolfram.—This substance, which appears almost invariably to accompany the ores of tin, is to be found in the Wicklow sand, in small grains pretty extensively diffused, though not on the whole constituting any very large proportion of the deposit.

Oxide of Manganese.—This is found in small pebbles and fragments of reniform masses, externally polished by attrition, but, when broken, exhibiting very little lustre on the surfaces of fracture. They are of a bluish-grey colour, and uniformly massive, presenting no traces of crystallization. They are by no means pure oxide of Manganese, but contain a good deal of iron, and some earthy impurities.

Copper Pyrites occurs in very small quantity in minute grains disseminated through the sand. It also exists in a curious mineral compounded of micaceous iron and copper pyrites, which has been found at one of the shafts sunk in search of gold.

Galena is found in the rocks adjoining the banks of the stream, where there are now some shafts being sunk for the purpose of extracting it. It is sometimes to be found, though in extremely small quantity, in the auriferous sand itself.

Sulphuret of Molybdenum.—In one part of the stream, I found a few rolled grains of this mineral, but it does not appear to be extensively diffused through the sand, or to occur in any considerable quantity.

All the preceding minerals belong to the class of metallic ores, but the sand also contains a great variety of earthy minerals, some of which are very rare in this country. The first of these to be noticed is

SAPPHIRE.—It is found in rounded pebbles of a beautiful dark-blue colour, but very nearly opaque, or at least only translucent on the edges. They do not present any trace of crystallization.* They possess quite the same degree of hardness as the specimens from Ceylon, scratching topaz, and even chrysoberyl with ease. The specific gravity of the only piece which I was able to obtain was 3.948. These pebbles are extremely rare in the Wicklow sand, but very few of them having yet been found.

TOPAZ.—This mineral is also very seldom met with in this locality. It is in colourless grains, which are principally remarkable from the very slight alteration of their form by attrition.

ZIRCON occurs in small rolled grains of a dull brownish red colour, and presenting in a slight degree the peculiar lustre which is so characteristic of this mineral. It exists in but *very* small quantity in the sand.

GARNET occurs of two different species.

1st—A mineral of a dark red colour, in grains almost exactly resembling pyrope, which, however, it does not appear to be, as some of the grains present faces belonging to the regular rhombic dodecahedron. It is very rare in the Wicklow sand.

2nd—Another species of a very much lighter colour, and in *very* small grains, never exceeding the size of mustard seed. Under the microscope, their dodecahedral form becomes visible, the edges of the crystals being slightly rounded. Their specific gravity is 4.196. Before the blowpipe, the phenomena due to Manganese are very distinct. They gave, on analysis,

Silica,	35.77
Alumina,	19.85
Lime,	Trace
Protoxide Iron,	38.07
Protoxide Manganese,	5.04
	98.73

* I have found in the finer portion of the sand a very small grain, consisting of two or three minute six-sided prisms of a blue colour, which appears to be sapphire, but its minute size precludes the possibility of determining this with certainty.

They therefore belong to the class of manganesian garnets. These grains occur in very large quantity in the sand, and are uniformly to be found along with the heavy minerals at a particular period of the washing.

Quartz is to be found in small crystals, and in amorphous masses of various sizes. It varies from transparent to nearly opaque, and generally occurs colourless, but is sometimes found tinged with various shades of yellow and brownish red. It is also occasionally intimately penetrated by chlorite, producing the variety to which the name Prase has been given.

Augite occurs in very small abraded crystals of a brown colour. They present the form of oblique six-sided prisms. They are to be found in but small quantity in the sand.

Chlorite.—This mineral occurs in very considerable quantity, principally imbedded in quartz and micaceous iron. It is quite similar to ordinary specimens from other localities.

Felspar and Mica.—Both these minerals are found in the sand, and are obviously the products of the disintegration of the adjoining granite, which resembles in every respect that which is found all through Wicklow.

The preceding list comprises all the simple minerals which I have been able to detect in this sand, the remainder of which consists of the detritus of the adjoining rocks, which are principally clay-slate and mica-slate. The greater number of the minerals here enumerated are mentioned by Mr. Weaver in his reports to government on the district, and which are to be found in the Transactions of the Royal Dublin Society; but some of them have, I believe, not been noticed before, at least I have seen no published account of the occurrence in this locality of Platina, Titanic Iron, Sulphuret of Molybdenum, Topaz, Zircon, the small Manganesian Garnets, or Augite. Hence it seemed interesting, while noticing these, to collect into a uniform and as far as possible complete list, all the scattered notices of the mineral wealth of this particular district, which are to be found in Mr. Weaver's papers already referred to, and elsewhere.

The principal point, however, with respect to the examination of these minerals, which appears to merit further and more particular attention, from some one better qualified for the task, is the fact of the

existence of Tinstone in such considerable quantity in these auriferous streams : a fact which would seem to indicate the probable existence somewhere in the surrounding district, of masses of the ore of this valuable metal of great extent, and possibly forming the continuation, on this side of the channel, of those vast deposits which have contributed to furnish occupation and support to the inhabitants of Cornwall for more than two thousand years.

"On the effects of lateral pressure in producing curvatures, in rock-strata;" by EBENEZER E. BARRINGTON, ESQ. C.E. Communicated by PROFESSOR OLDHAM, Secretary to the Society.

IT is not proposed in the following remarks, to enter into any enquiry as to the source or cause of such pressures or forces as may have acted on the stratified rocks forming the earth's crust, but simply to enquire what the result of the action of such forces will be, granting their existence.

The force so exerted endways on a stratum, or series of strata, may act in one of three different ways.

1. As an impulse; in which case the result would be, that it would communicate to the mass acted upon (neglecting elasticity, and supposing this mass not to be in contact with other bodies) a sudden velocity, equal to $\frac{M\,v}{M+M_1}$

M representing the mass of the striking body; v, its velocity; and M_1 the mass of the body struck.

If this velocity be prevented by any obstacle, the body struck must break in pieces, unless the cohesion of the particles is able to overcome the motive force communicated by the impulse, in which latter case the effect depends on the elasticity. Indeed, even though the body were in empty space, or in a medium which generated but little friction, this suddenly acquired velocity, being first communicated to the particles nearest to the moving power, might cause them to separate, divide, or scatter from the further or more distant particles, in any case of insufficient cohesive power. But this is not important.

2ndly. It might be a simple force, of such a nature that its action must be slow; that is, to speak with reference to geological questions, that any velocity communicated by its means to strata, would, (since the masses moving must follow the masses moved, in order to continue the action,) generate such an amount of friction in the masses which exercise the motive power, as to diminish that power; and so by les-

sening the force in proportion to the rapidity of the action, cause a *gradual* change in the position of the beds acted upon.

3rdly. We can conceive a simple force applied to strata, such that it is not materially affected by its own action.

Now I conceive that the second case stated above, is that most frequently at work in the crust of the earth. If, however, our object be to determine the position of equilibrium, the third will obviously lead to the same results.

The mass acted upon may be also divided into three kinds. 1st, fluid; 2nd, solid; 3rd, laminated; the latter being considered as first, without lateral cohesion of the laminæ, and secondly, with a certain amount, but this amount very much inferior to that of the transverse cohesion.

1. Regarding the first kind, the fundamental principle of hydrostatics, that fluids transmit pressures equally in every direction, is well known.

2. In the case of a solid, the effect will be so modified by peculiar circumstances, that we shall dispense with the consideration of them as much as possible, and consider the simple case of a parallelopipedon of nearly uniform structure, acted on by a force uniformly distributed over one end to which it is applied. The result here would be, that a wedge would be broken off, making, according to one theory, half a right angle; by another principle, an angle somewhat greater, with the side to which the force is applied.

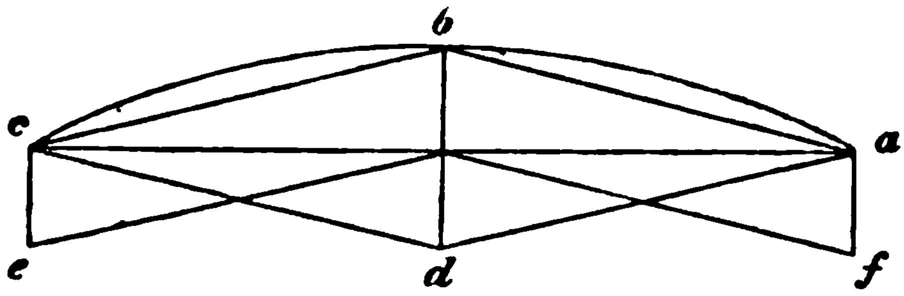
3. In the case of a laminated mass, the strata subjected to the force may be under three conditions: (*a*) isolated; (*b*) in contact with other rocks on *one* side; (*c*) in contact with other rocks on *both* sides.

Before proceeding, however, it will be necessary to consider the nature of the action of a force applied to the ends, or endways, of an infinitely thin lamina. Supposing the lamina to be mathematically *in the same plane*, and that the force acts in that plane, it is clear, if the particles of the lamina be supposed incompressible, that the force will be equilibrated. If, however, the lamina* be not exactly in the same plane, but slightly curved, as in fig. 1, the force applied at *a*, resolved in the direction of *a b*, will, together with the reaction of the point *c*, in the direction of the line *c b*, give rise to a force in the direction of *d b*, equal to *d b*, if *a b* represent the component of the original force.

* In this theorem, the part of the lamina between *a* and *b*, and between *b* and *c*, is considered as possessing perfect rigidity, so as to be able to convey the force from *a* to *b*, and from *b* to *c*, just as if they were rectilinear instead of curved; and this for two reasons: first, because it is easy to show that the resultant will be greatest at the centre, (the curve being supposed symmetrical) and that the lamina would yield there first; secondly, that in the cases under which we shall consider the force as acting, the contiguous laminæ, or adjacent rocks, will effect the rigidity required.

N.B.—The force *a b*, strictly speaking, gives rise to a force in the direction *b c*, equal to $a\,b$ cos. $a\,b\,c$, and to a force perpendicular to $b\,c = a\,b$ sin. $a\,b\,c$; but this angle being supposed so obtuse, we have stated it generally as above, not meaning there to speak of the strictly exact values of the forces. If, however, the motion of *b* be prevented or resisted by a surface parallel to *a c*, then *b d* and *b c* will be the true values of the components.

Figure 1.



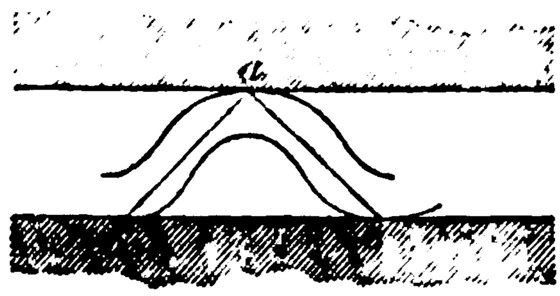
The other components of the applied force and of the reaction, viz.—$a\,f$ and $c\,e$, are also to be considered. They will cause the ends of the lamina to move towards f and e, with the same velocity, which is equal to one half of the velocity of the centre (b) in the other direction.

This is the result with a lamina in an isolated condition. Let us now consider the result in the second condition, when the lamina at a and c is in contact with a fixed surface, which constantly prevents the ends of the lamina from moving towards f or e. The result of this is, that the forces, $a\,f$ and $c\,e$, are counteracted by its resistance; while a force equal to $b\,d$ acts on the centre (b) in the direction of $d\,b$.

In the third condition (in contact with other laminæ on both sides) this force, $d\,b$, is met by the surface in contact at the other side, against which, therefore, the lamina exerts the pressure at b.

It is now easy to pass from the consideration of a lamina infinitely thin, to that of one of a finite thickness; for, as before, if the lamina be bounded by two parallel planes, to which the applied force is also parallel, this force must be equilibrated by its resistance, and can have no tendency to bend it; but if the bounding surfaces be curved,* and if the line joining the centres of gravity of the two ends cut either bounding surface, it is clear, that (as the forces, being equally distributed on their terminal surfaces, are equivalent to their sum acting at the terminal centre of gravity,) their effects will be to produce a *transverse resultant*, approximately proportional to the versine of the arc, cut off by the above line from the curve made by the intersection of a perpendicular plane through the centres of gravity with the lamina.

Figure 2.



Starting from this principle of a transverse resultant, we shall proceed to the general case of a laminated mass, i. e. a mass con-

* We suppose for simplicity, that the curved form of the lamina, when subjected to the force is such, that its intersection ith any plane perpendicular to the direction of the force, is a horizontal right line.

sisting of a number of parallel laminæ, acted upon by a force applied to their end, and consider it also under the above three conditions. We shall then see how a laminated mass is affected by lateral interminal pressure, in a manner, as it were, intermediate between that of the solid and the fluid.

1st. When isolated: this case, being one extremely unlikely to happen, we shall dismiss by saying, that before the result in the case of a solid mass would have taken place, the laminæ, owing to some trifling inclination or deviation from the plane in which the force acts, would be forced outwards by the transverse resultant mentioned above, which might be in a different direction for different laminæ, and so might cause them to separate in the centre, when the transverse resultant increasing with the curvature of the laminæ, the whole mass would rapidly give way.

If a certain cohesion existed between two contiguous laminæ, the mass would not give way, until the difference between the transverse resultants, which move the laminæ to each side, would be able to overcome the elastic force, if elastic, or otherwise the cohesion of the laminæ on their cross section, unless, indeed, the *least* of the two resultants were greater than the cohesive power on the longitudinal section, when the only extra effect of the cohesion would be, perhaps, to change slightly the point of separation.

2ndly. With rocks at one side, and without lateral cohesion: then the transverse motion would be prevented at one side, by the rocks in contact there. If, then, the combined effect of all the resultants were to move any lamina from the fixed rock, that motion would take place; if it were to move any lamina towards the fixed rock, the result might be either the crushing these rocks, or their yielding in some other part to a resultant in the opposite direction; for the resistance of the fixed rocks might modify the applied force, so as to produce intermediate resultants from these rocks.

This case would become modified by lateral cohesion of the lamina as follows: if the sum of the resultants *from* the fixed rocks were greater than *towards* them, all the laminæ, or strata, would move in that direction, unless the general resultant of any part was towards the fixed rocks, and also able to overcome the cohesion of its separating plane, before the force had become great enough to bend the whole, in which case, the lateral cohesion could only effect the line of division; and *vice versa*, if the sum of the resultants *towards* the fixed rocks be greater than *from* them, the mass will be as if solid, until the resultant of some part at the off side be *from* these rocks,

and also able to overcome the lateral cohesion of the longitudinal divisional plane which separates it. In either case, the part divided towards the fixed rocks would either be crushed, and so by its fragments fill up the hollow formed by the bend of the other part, or it would be forced from these rocks at some other point, when the general resultant was in that direction.

In the third case, where the strata acted on are enclosed between rocks above and below, it is obvious that if these rocks be absolutely fixed on both sides, that those acted on by the force, not being permitted to bend as a lamina, or to chip off as a solid mass, will effectually resist the force applied, excepting so far as they may be compressed, and when a certain amount of compression has taken place, there will be equilibrium.

However we may suppose the rocks on one side to be fixed, those on the other being merely held by their own weight, in which case, as soon as the resultant in the upper direction is able to overcome their weight, it will raise the superincumbent rocks. But their weight or reaction will again modify the final effect; for it being resolved into two directions, ($a\,b$) and ($a\,c$,) the component $a\,c$ equiliberates the force applied, producing at the same time a pressure at c downwards, while the component $a\,b$ gives rise to a pressure downwards, at b, and at the same time to a horizontal force, which tends to produce in the further parts of the strata, an action similar to that of the original force.

As a certain amount of original force is spent in overcoming friction, the action or effort must diminish for every successive wave, or bend rapidly. Nevertheless, as we may suppose the friction inconsiderable, as compared with the force applied, there may be found a series of such waves or bends as above. And it may here be mentioned, that, *but for the friction*, the action of the force being continued through the whole length of the strata, one particle communicating it to the next, the first bend would be formed wherever the combined effects of the rigidity of the strata themselves, and the weight of the overlying rocks, which are the resistance to the formation of these bands, were least. The friction causes the first bend to be made near the point of application of the force.

We would remark also, that the effect of the downward pressures at b and c (above) may be similar to that of the pillars which support the roof of a mine; they may cause that part of the lower

rock underneath the centre of the bend, to rise gradually, and fill the hollow, or partially hollow, space formed. And in like manner, the weight of the overlying beds may cause them to fall gradually, and fill in the alternate sinus.

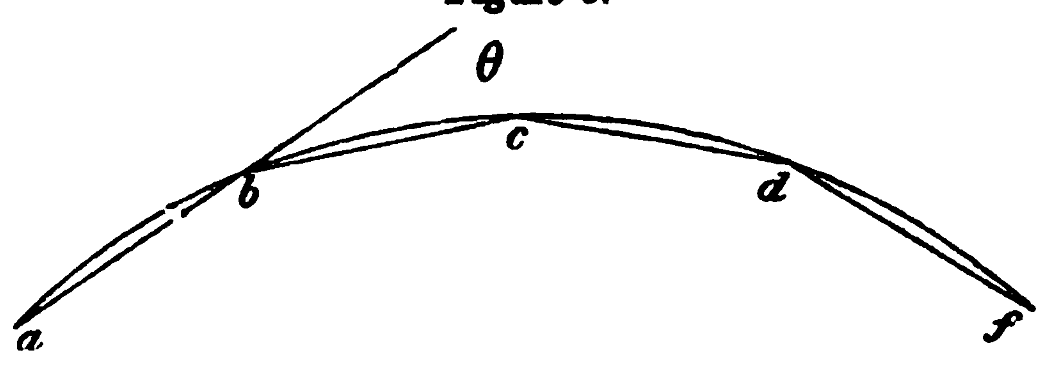
In the preceding remarks we considered the effect of the application of a force to the terminal plane of a thin lamina, supposed slightly bent, and such, that the two parts of the lamina, on either side of the point furthest removed from the direction of the force, were rigid, and were therefore capable of transmitting forces. Thus if two beams, *a b* and *c b*, (fig. 1, page 279,) were resting against each other, at *b*, and that a force (F) acts at *a*, in the direction *a c*. it was merely stated, according to the parallelogram of forces, that the component of F, in the direction of *a b*, with the reaction of the point *c*, in the direction of *c b*, gives rise to an upward force at *b*, varying according to the position of the opposing plane, to which its direction must be perpendicular.

If in such a case *c* be supposed fixed, and *c b* incompressible, the point *b* is constrained to move in a circle whose centre is *c*, and whose radius is *c b*; and the resultant upward force in that case perpendicular to *c b*, will be a maximum, when the angle *a b c* is a right angle.

The hypothesis of *rigidity* being, however, scarcely applicable to rock strata, let us consider the subject in a more legitimate point of view.

For this purpose, let us imagine a number of bars of equal length, capable of resisting compression, and having their ends in contact with a fixed curve, which, for simplicity, we shall consider a circle.

Figure 3.



A force, F, being applied at *a*, in the direction *a b*, and (*f*) being a fixed point, it is required to find the pressure against the fixed curve, and also against the point, *f*, (*friction not being taken into account.*) In this case the force F is resolved at *b*, into a normal force, $= 2\ \mathrm{F}\ \sin.\ \frac{\theta}{2}$ (θ being the external angle between two con-

secutive bars,) and a force, $= F$ in the direction of $b\,c$, which again is of course similarly resolved into a normal force at $c = 2\ F \sin. \frac{\theta}{2}$ and a force $=$ F along $c\,d$. The force F, applied at b, in the direction of $a\,b$, gives rise, therefore, to a pressure, $= 2\ F \sin. \frac{\theta}{2}$ against the curve at all the points of contact, and to a reaction at f, equal to itself, all the bars being subjected to a compressive force $=$ F also.

Further, if (α) denote the inclination of any side to the axis of (x) and (a) the inclination of ($a\,b$) to the same, since the principle of the funicular polygon (that all the forces transferred to any point form an equilibrium) holds here, we have, calling as above, the compressing force along any side F, and the normal pressure, N,

$$- F \cos. \alpha_n = - F \cos. a + \lesseqgtr N \sin. \left(\alpha + \frac{\theta}{2} \right)$$

Supposing now the number of these bars to become infinite, we shall have an incompressible ring in contact with the concave side, so to speak, of a fixed circle, and it is required to find the pressure against the curve resulting from the application of a force F, at one end of the ring, inthe direction of the tangent at the point of application.

The compressive force is then every where the same, and equal to F by last proposition; but the normal force, or the reaction of the curve at any point, is infinitely smaller than the compression. This appears from the equation $N = 2\ F \sin. \frac{\theta}{2}$; because θ being $=$ O, $N =$ O. Wherefore, in order to compare the normal force with the force applied, we must take it not for a mathematical point, but for some definite portion of the curve.

But before proceeding to estimate the reaction, let us advance to a case somewhat more general, and consider a fixed curve of any form of single curvature; and showing that the compressive force remains the same for all parts of the curve, proceed to consider the amount of the normal force or reaction in this general case.

Considering, then, three consecutive points on the curve, or two consecutive elements, let the force F act in one, and the force F′ in the other. As the three points are on the circumference of the osculating circle, and as we have proved that in the case of a circle, the forces acting in the two consecutive elements are equal, it follows that they are also equal in this case, and therefore, by proceeding from element to element, it appears that the compressive force is the same throughout the curve.*

* In order to be satisfied of this, let us apply to the case in question the following proposition: If any three forces form equilibrium at any point, the difference between any two is to the third, as the sin. of ½ diff. of the angles that the latter makes with the two former, is to the sin. ½ sum of same angles. We have therefore the difference between the two forces compressing each element—

: The reaction at the intermediate point.

: : Sin. ½ difference of the angles, which the tangent makes with the consecutive elements.

: Sin. ½ angle contained by them.

The difference between the forces acting in each element, is, therefore, infinitely less than

Having now established the equality of the compressive force for all parts of the curve, we proceed to estimate the amount of pressure against it, or the reaction.

In the case of an equilateral polygon, we have shown that

$$-\mathrm{F}\cos. a_n = -\mathrm{F}\cos. a + \sum \mathrm{N}\sin.\left(a + \frac{\theta}{2}\right)$$

when

F = force applied, which is = compression.
$a\ a\ a_1\ a_2\ \ldots\ a_n$ inclination of sides to axis of x.
N = normal pressure.
θ = External angle between two consecutive sides.
$\sum$ = sum for all the (n) points of reaction.

If, then, the polygon have an infinite number of sides, or, in other words, becomes a curve, we shall have

$$-\mathrm{F}\cos. a = -\mathrm{F}\cos. a + \int \mathrm{N}\sin. a\, d s,$$

N being supposed constant for the element $d s$, and to represent a pressure = to that at $d s$, applied along a unit of length, a being the angle made by the tangent at the first point of any element, $d s$, with the axis of x, and a the inclination to the same axis of the force F, which is applied tangentically at the beginning of the curve, θ of course having become equal to O. Now differentiating, we have $\mathrm{F}\,d a = \mathrm{N}\,d s$: but $d a = \frac{d s}{\rho}$; therefore $\frac{\mathrm{F}\,d s}{\rho} = \mathrm{N}\,d s$, or $\mathrm{N} = \frac{\mathrm{F}}{\rho}$; that is, the normal pressure exerted against the curve at any point is proportional to the force applied directly, and inversely, as the radius of curvature at that point.

To estimate the amount of this force, we shall return to the equation $\mathrm{N}\,d s = \mathrm{F}\,d a$, and by integrating we obtain

$$\int \mathrm{N}\,d s \text{ (or total pressure)} = \mathrm{F}\int d a = \mathrm{F}\,a'$$

when a' is the angle between tangents at first and last points.

Let us now proceed to apply this proposition to determine what will be the effect on bedded rocks, of a pressure acting on them in the direction of their planes of bedding. We shall take for granted that the planes acted upon are slightly bent, that is, not in the same plane as force applied, mathematically; for there are many causes tending to raise and depress the beds, even if originally deposited exactly in planes; besides, the very action of lateral force, would, by crushing some beds, tend to derange the perfect regularity of others. And we shall also consider the fixed curve of our proposition as represented by underlying or overlying rocks. We shall then

the pressure against the curve or the reaction; but we have previously shown, that this pressure required to act over a definite portion of the curve to be itself estimated, being infinitely smaller than the compression: it follows, therefore, that even for a definite portion of the curve, the difference between the compressive force at its extremities is infinitely small.

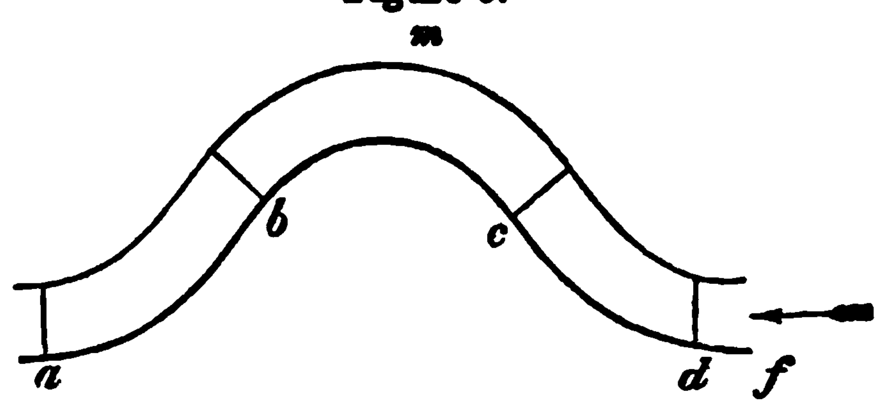
have as in figure 3, confining ourselves at first to a single bed, a

Figure 4.

force acting at *d* in the direction of *f d*, on the bed or stratum *f d c b a*, to find the different pressures resulting therefrom, first disregarding friction. We shall here premise that it is necessary to consider the stratum as first curved downwards, then at a certain point *c* without any curvature, and after that curving upwards, as far as the point *b*, when the curvature again changes, and finally becoming at (*a*) again horizontal; this is necessary to avoid any angular point, and is obviously the most likely form for the stratum to assume.

There is, then, evidently by our proposition a normal pressure downwards from *d* to *c*; upwards from *c* to *b*; and downwards from *b* to *a*. Supposing this pressure to be strong enough to overcome to a certain extent the resistance of the adjacent masses, the stratum will tend to become more curved, its next stage being, as it were, represented by fig. 5.

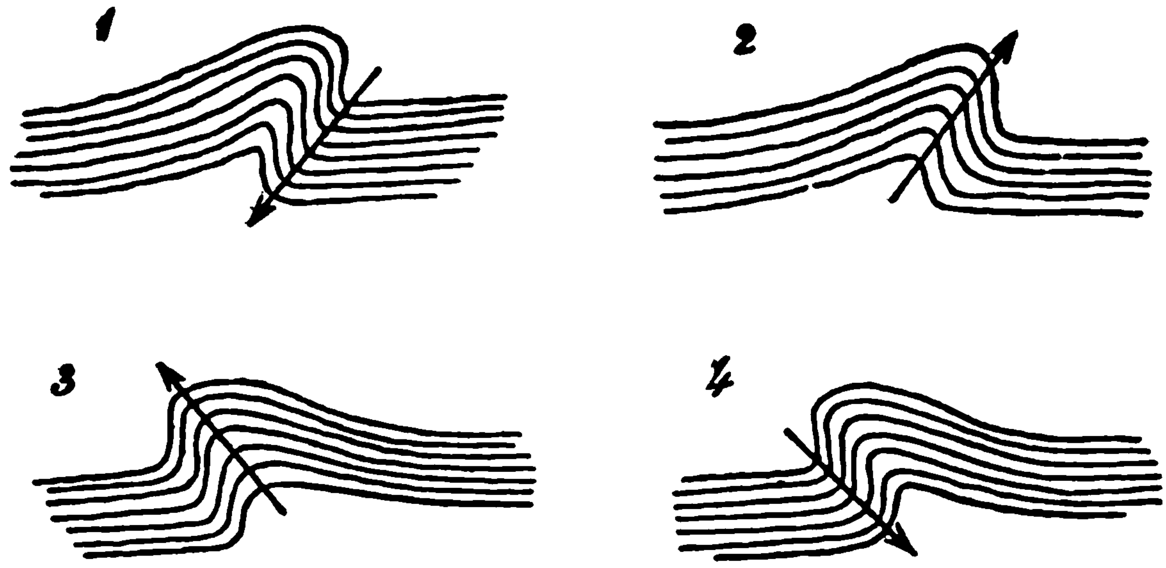
Figure 5.



Proceeding to consider the form which the stratum may assume, should the adjacent beds give way to the pressure exerted upon them, let us suppose these beds above and below to have been originally conformable with that acted upon; it is clear, then, that the resistance to the pressure exerted vertically upwards, will be much greater than that at the sides (so to speak) of the bend, (the overlying masses being considered as very great compared with that of the stratum itself.) We may, therefore, divide the curve into four parts, in any one of which, if the yielding take place, the

final position of the stratum will be different, viz.—from *d* to *c*; from *c* to *m*; from *m* to *b*; from *b* to *a*; these different positions being represented as follows :—

Figure 6.



Theoretically speaking, the friction will, by diminishing the compressive force, tend also to diminish the normal pressure, which will be, therefore, greatest near the source of pressure. In a single bend, the yielding would, according to this, be most likely to take place as in No. 1, least likely as in No. 4. But the varying nature of the stratum acted upon, as well as of the contiguous strata, would be much more likely to determine the point of yielding than any change in the pressure produced by friction.

Having thus attempted to exhibit the effects in the case of a single bend, let us consider the case when more than one curve may have been formed:

In order to do this, it is only necessary to consider the compressive force at (*a*) as an originally applied force, producing a second bend in the same way as the first was formed, and so on for a third, fourth, &c. &c.

Disregarding friction, it is obvious that the compressing force will continue uniform throughout the series of curves, which will therefore extend, until some change in the strata, independent of this force, impedes their formation. When friction is taken into account, it will, of course, diminish the compressive force, as we proceed from the extremity at which it is applied, and therefore, the magnitude of the curvatures or contortions; but it is thought, that if a number of conformable beds be simultaneously acted upon, the friction *against* the upper surface of one reacting as an additional force on the

lower surface of the one above, in the opposite direction, all the friction may be disregarded, except that at the lower surface of the lowest, and the upper surface of the highest bed; and that although the force F will be diminished in a degree by this friction, at each successive bend, yet we may still presume a number of bends to be formed, decreasing in size as the compressive force decreases.

Again, if a yielding should take place at any curve, the force may be transmitted through the medium of the crushed rocks; and we may thus have, under the influence of a constant pressure, any number of bends or contortions, fractured or otherwise, produced in the same stratum, or series of strata.

In the case where there is no superincumbent rock, the normal pressure downwards may be supposed counteracted by the rocks below, as before; and that upwards to be resisted by the weight of the mass of the stratum or strata acted upon, which resolved in the direction of the normal to the bend, which the strata have assumed, may, although not accurately equal to it, counteract the normal pressure, the rigidity of the strata maintaining the equilibrium.

As the force required to elevate the curve or bend of the strata, diminishes as the curvature increases, it appears, that once the strata have begun to assume the curvilinear shape, they will, if the pressure be constant, continue bending, until fracture takes place, and that no other bend can be formed until this result has happened. If, however, we consider, that the friction which impedes the transmission of the applied force to affect the further parts of the strata is, diminished, as soon as the first portion of the strata where it acts has begun to bend upwards, it will be seen that at that moment, a second or a third bend may begin to be formed; that bend, however, which under the circumstances is most easily formed, will proceed to its yielding point before the others can be developed. In this way a series of broken curves may be formed.

Lastly: if a considerable thickness of strata be acted upon, or if the influence of the pressure extend only to a certain distance from its source, we may have a number of regular unbroken undulations, without any superincumbent rocks.

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1853.

CONTENTS OF VOL. V.

DIRECTIONS TO THE BINDER.

AT

THE ANNUAL GENERAL MEETING,

HELD AT

35, TRINITY COLLEGE,

ON

WEDNESDAY, FEBRUARY 12TH, 1851,

LIEUTENANT-COLONEL PORTLOCK, R.E., PRESIDENT,
IN THE CHAIR,

The following Report from the Council was read and adopted:

Report of the Council of the Geological Society of Dublin, for the Year 1850-1851.

THE Council presents to the Society the following Report as to its movements for the past year.

Eight new Members have been added to the Society, viz.:— Nathaniel Hone, Esq.; Francis Codd, Esq.; Thomas O'Brien, Esq.; Edward Grattan Holt, Esq.; Hans H. Allen, Esq.; Richard Hitchcock, Esq. (Assistant Secretary); Henry Head, Esq., M.D.; and Lord Talbot de Malahide.

Three Associates, viz.:—Alexander Jack, Esq.; Alexander Macdonnell, Esq.; and Thaddeus O'Malley, Esq.

Three Members have withdrawn:—A. W. Domville, Esq.; Frederick Burton, Esq., R.H.A.; and Thomas Oldham, Esq., F.R.S.

The withdrawal of the second the Council regrets to find has been caused by a severe family affliction by death; and in Mr. Oldham's case by his departure to India, to take the direction of the Indian Geological Survey. His absence cannot but be viewed as a loss to Irish Geology.

The Society does not appear to have sustained any loss by death during the year. It now numbers 4 Honorary Members, 35 Life Members, and 80 Annual Members, and 4 Associates; total, 123.

It is to be regretted that the opening of the advantages of the Society to the Class of Associates, at the nominal fee of *5s.*, does not appear to have been as fully appreciated as the Society expected.

No papers of adequate merits were presented during the year, and prior to December, 1850, to enable the Council to award any one of the three prizes offered publicly by the Society.

The Trust Fund from Life Compositions continues untouched.

The Council has taken measures for reducing the cost of publication of the Society's transactions in future, and, when the existing liabilities are paid, trusts that there will be no diminution in the extent or value of this department of our labours.

The Treasurer's account shows that our liabilities amount to about £66; that there is lodged in bank, exclusive of the Trust Fund from Life Compositions, about £30; and that the subscriptions due, and in process of collection, may be supposed capable of meeting the balance of claims at present against the Society.

The following lists contain the donations made to our library during the past year.

GEOLOGICAL SOCIETY.

DONATIONS RECEIVED SINCE LAST ANNIVERSARY.

1849.

Aug. 3. Geological Map of the County of Kildare. Presented by the Chief Commissioner of Woods and Forests, through Sir Henry T. De La Beche.

1850.

Feb. 22.—Quarterly Journal of the Geological Society of London, No. 21. Presented by the Society.

May 1.—Transactions of the Royal Scottish Society of Arts, Vol. III., Part 4. Presented by the Society.

June 4.—Quarterly Journal of the Geological Society of London, No. 22. Presented by the Society.

June 15.—Reports of the Dublin Natural History Society, Eighth and Ninth. Presented by the Society.

June 15.—Proceedings of the Royal Irish Academy, Part 8, Vol. III., Parts 1 to 3; and Vol. IV., Parts 1, 2. Presented by the Academy.

June 19.—Address to the Geological Society of London, Feb. 15, 1850. By Sir Charles Lyell, F.R.S., &c. Presented by the Author.

June 26.—Proceedings of the Royal Irish Academy, Parts 1 to 4. Presented by the Academy.

June 27.—Proceedings of the Literary and Philosophical Society of Liverpool, Nos. 1 to 3. Presented by the Society.

July 1.—Reports of the Natural History Society of Northumberland, Durham, and Newcastle-upon-Tyne, for the Years 1839 to 1849 inclusive. Presented by the Society.

July 9.—Memoirs of the Wernerian Natural History Society, Vol. VII. and Vol. VIII., Part 1. Presented by the Society.

July 12.—Proceedings of the Linnæan Society, Nos. 1 to 41, with List of the Society, 1849. Presented by the Society.

July 30.—Transactions of the Philosophical and Literary Society of Leeds, Vol. I., Part 1. Presented by the Society.

1850.

July 30.—Account of an Egyptian Mummy, presented to the Museum of the Leeds Philosophical and Literary Society by the late John Blayds, Esq. Presented by the Society.

July 30.—Reports of Council of the Leeds Philosophical and Literary Society, Nos. 5 to 7—11, 12—14 to 29 (Leeds, 1825–49). Presented by the Society.

July 30.—Reports of Proceedings of the Geological and Polytechnic Society of the West Riding of Yorkshire, Vol. II. pp. 1–102, and Vol. III. pp. 1–108. Presented by the Society.

Aug. 29.—Quarterly Journal of the Geological Society of London, No. 23. Presented by the Society.

Sept. 6.—Athenæum, Annual Report, General Abstract of Accounts, &c., for 1849. Presented by the Club.

Sept. 16.—Proceedings of the Zoological Society of London, Nos. 1 to 154, 163, 164, and 177 to 189, with Reports for 1848 and 1849. Presented by the Society.

Sept. 18.—Memoirs of the Geological Survey of the United Kingdom; Figures and Descriptions Illustrative of British Organic Remains, Decade III. Presented by the Chief Commissioner of Woods and Forest.

Oct. 3.—Journal of the Royal Geographical Society of London, Vol. XX., Part 1. Presented by the Society.

Nov. 6.—Transactions of the Geological Society of London, Vol. IV., Part 2; Vol. V., Parts 1 to 3; Vol. VI., Parts 1, 2; and Vol. VII., Parts 1 to 3. Presented by the Society.

Nov. 13.—Report of the British Association for the Advancement of Science, for 1849. Presented by the Association.

Nov. 13.—Conybeare and Phillips' Geology of England and Wales, Part 1. Presented by Professor Oldham.

Nov. 13.—Dove's Maps of the Monthly Isothermal Lines of the Globe. Presented by Professor Oldham.

Dec. 11.—Proceedings of the Zoological Society of London, Nos. 190 to 200, with Reports of Council, &c. Presented by the Society.

Dec. 16.—Quarterly Journal of the Geological Society of London, No. 24. Presented by the Society.

Dec. 18.—Transactions of the Kilkenny Archæological Society, for the Year 1849. Presented by the Society.

Geological Society.—Abstract of Accounts for the Year ending February, 1851.

Dr.	£	s.	d.
To Life Subscriptions—			
Of Mr. W. S. Wilson, ...	5	0	0
Of Mr. N. Hone, ...	10	0	0
„ Payment by the Commissioners of Public Works for Furniture, ...	10	0	0
„ Admission Fees, per Annexed List, .	8	0	0
„ Annual Subscriptions, Do. . . .	66	10	0
„ Interest on Government 3¼ per cent. Stock, viz:—			
On £70 6*s*. 10*d*. for the half-year, to 6th April, 1850, ...	1	2	10
On £80 12*s*. 3*d*. for the half-year, to 10th October, 1850, ...	1	6	2
„ Received from the Rev. S. Haughton for Books, ...	1	0	0
	£102	19	0

12th February, 1851.

Cr.	£	s.	d.	£	s.	d.
By Balance due by the Society on the last Year's Account, ...				13	6	1½
„ Collector's Poundage, ...				3	14	6
„ Cost of £15 6*s*. 10*d*. of 3¼ per cent. Stock, at £96 2*s*. 6*d*., per Broker's Account, . .	£15	0	0			
„ Cost of £10 5*s*. 5*d*. Ditto, at £96 15*s*., per Ditto, . .	10	0	0			
				25	0	0
„ Sundry small expenses, ...				4	14	0
„ Assistant Secretary's Salary, half-year, to 14th Aug., 1850,	£10	0	0			
„ Sundry small expenses, . .	4	18	0			
				14	18	0
„ Assistant Secretary's Salary for half-year to 14th Feb. 1851,	£10	0	0			
„ Sundry small expenses, .	1	12	6			
				11	12	6
„ Balance in the Treasurer's hands, .				29	13	10½
				£102	19	0

Examined, J. PORTLOCK, *President*.

A Ballot then took place when the following Gentlemen were elected Officers of the Society for the ensuing Year:—

President:

LIEUT.-COL. PORTLOCK, R.E.

Vice-Presidents:

JAMES APJOHN, ESQ. M.D.
RICHARD GRIFFITH, ESQ. LL.D.
REV. H. LLOYD, D.D. S.F.T.C.D.
RT. HON. THE LORD CHANCELLOR.
THE ARCHBISHOP OF DUBLIN.

Treasurers:

WILLIAM EDINGTON, ESQ.
SAMUEL DOWNING, ESQ.

Secretaries:

ROBERT MALLET, ESQ.
REV. S. HAUGHTON, F.T.C.D.

Council:

C. W. HAMILTON, ESQ.
JOHN MACDONNELL, ESQ. M.D.
PROFESSOR HARRISON, M.D.
CHARLES P. CROKER, ESQ. M.D.
THOMAS HUTTON, ESQ.
ROBERT BALL, ESQ. LL.D.
ROBERT CALLWELL, ESQ.
PROFESSOR ALLMAN.
PROFESSOR HARVEY.
REV. J. A. GALBRAITH, F.T.C.D.
F. J. SIDNEY, ESQ. LL.D.
JOHN KELLY, ESQ.
BARRY D. GIBBONS, ESQ.
JOHN PETHERICK, ESQ.
JOHN KING, ESQ.

ADDRESS.

On addressing you again, Gentlemen, after a lapse of so many years, from this Chair, I may be permitted to express my satisfaction at seeing a Society of which I was an original member, and with which I have been so intimately connected, still successfully and vigorously pursuing its useful and honorable course; and, let me add, that personally I have an additional gratification in observing still amongst you so many of my old and respected friends, with whose names the labours and fame of the Geological Society of Dublin will ever be associated.

It appears to me that on an occasion of this kind I shall best consult the interests of Science, and the wishes of the Society, by briefly considering the objects which ought to occupy the attention of a geologist, and bringing before you some of them, illustrative of the philosophical results of geological inquiry, which are suggested by the subjects which have occupied our attention during the past Session. In pursuing the study of the history of the Earth, and as a student of that history we must consider the geologist, we are taught to recognise an intimate, though sometimes, it may appear, a mysterious and uncertain connexion between the mineral or inorganic, and the organic divisions of nature. From the rock to the plant, and from the plant to the animal, there is a continued chain, not of affinities but of dependencies, and on that account it is that the geologist is becoming, more and more, as knowledge progresses, the fellow-labourer of the botanist, the zoologist, and, even in more practical matters, of the agriculturist, the merchant, the miner, the quarryman, and, I will even say, of the soldier. Such is the result of a practical examination of our subject; but when it is looked at by the philosopher, he learns by the study of the earth many most interesting

and startling facts: in its crust he discovers evidences of successive disturbances on the one hand, and of the most harmonious arrangements on the other. He finds the proofs of the devastating influences of ancient volcanoes, earthquakes, torrents, floods, and other physical agencies, as well as the softening and order-giving effects of creative power and vital agencies. He observes that matter, even when not imbued with vital energies, is still regulated by fixed and unalterable laws, and he sees in the inanimate crystal, or the definite compound, proofs of a power as great, though it may not appear at first so striking, as that which is manifested in all the wonderful structures of the animal and vegetable kingdoms.

The knowledge he thus acquires leads him to recognise two distinct, though closely associated, branches of geological research; and, whilst he endeavours to study and describe the successive Faunæ and Floræ which his examination of the earth's crust has made known to him, he feels that it is also necessary to explain the mineral changes and unravel the phenomena connected with the destruction of one set of created and living beings, and the appearance and relations of a succeeding one.

Geology, therefore, divides itself into two great branches, physical or inorganic geology, and natural or organic geology, neither of which can be neglected without leading to an imperfect knowledge of the whole. The various accidents which have affected the crust of the earth; the elevations and depressions of portions of its surface; the intrusion of molten mineral matter, or its outpouring in lava currents; the mighty denudations which have swept away vast masses of strata; the decomposition and degradation of mineral masses; the deposition, induration, and metamorphosis of others; the veins which traverse the rocks, and the minerals which are collected in them: all these, and other phenomena, are connected with the great laws of matter generally; whilst the relics of past organic creatures, though also under the control of the laws of matter, contribute to the geologist a still higher knowledge, as they establish the modifying influences of vitality, acting also as if regulated by distinct laws. Whilst, however, there is a practical distinction between these two branches of our subject, it must be remembered that the laws of matter are

never suspended, and that they proceed undeviatingly towards the great end of their institution, notwithstanding the occasional peculiarities impressed upon them by vital action.

On this principle of division I shall class the several Papers read, namely—under physical geology, those which relate to any of the phenomena which are connected with the mineral condition of the earth, such as the intrusion of igneous rocks, the elevation or depression of the surface, the contortion of strata, the wearing action of currents and of glaciers, the mineral composition of rocks, the distribution of minerals; and in organic geology, every thing which relates to the inhabitants of the earth at successive epochs of its history.

An examination of the mineral crust of the earth has long since made manifest the disturbances which have affected strata, now apparently imbued with all the elements of stability; and it has been the constant aim of philosophers to connect the visible effects, as exhibited in induration, crystallization, structure, veins, faults, contortions, with some sufficient proximate cause. Heat and pressure acting on loosely aggregated mineral matter, heated steam, the undulatory movement of a liquid nucleus, the contraction of the crust resting on that nucleus, volcanic agencies in whatever way excited, earthquakes, &c., have all been tried in aid of explanation, and we may now add the attempt of Mr. Stevenson M'Adam, of Edinburgh,* to apply the theory of M. Boutigny d'Evreux, a French chemist, who has lately created much sensation by reviving our knowledge of a peculiar property of fluids, in what he calls the spheroidal state, and explaining by it many of those remarkable facts which in past ages appeared miraculous, such as the incombustible man, or the ordeal by fire in which the hand was plunged unhurt into a bath of molten lead. Mr. M'Adam thus states his view of the condition of the earth.

1. A central nucleus in a state of igneous fusion.

2. A crust, at a comparatively low temperature, the inner side of which is in the spheroidal state.

3. A space between the crust and the central nucleus, possibly filled with vaporized mineral matter.

* Jameson's Jour. Feb. 1851.

As one property of bodies in the supposed spheroidal state is repulsion of heat, it is presumed by Mr. M'Adam that the heat is always reflected from the inner surface of the crust, which, therefore, remains unaltered in temperature; and with this theory he combines the steam and chemical theory of volcanoes which are rendered intermittent by a sudden change from the spheroidal state to that of steam. In this explanation Mr. M'Adam takes for granted that M. Boutigny's theory of that peculiar condition of bodies which he calls spheroidal, has been fully demonstrated; but it is not so, as another explanation of the phenomena has been advanced, and is still maintained by that eminent chemist, Person. M. Boutigny considers that when a fluid is thrown upon any substance, whether solid or liquid, heated to a temperature exceeding the boiling point of the fluid, it does not pass immediately into the state of vapour, but into an intermediate, "the spheroidal" state, in which its temperature is considerably below that of its boiling point. When bodies are in the spheroidal state M. Boutigny also considers that caloric exercises a repulsive power, even at sensible distances, and in this manner he explains the well-known phenomenon of a drop of water remaining for some time on a red hot iron, as well as that of the incombustibility of the human hand when plunged into molten lead or iron, the *rationale* in the latter case being this, that the moisture of the hand supplies water which passes into the spheroidal state, at a temperature greatly below that of boiling water, when its caloric repels the metal, and thus preserves the hand from contact with it.

In illustration of this theory M. Legal has subsequently shown that the only precaution necessary in such experiments is to use for the protecting fluid one of which the boiling point is considerably below that into which the hand is to be plunged; ether, for example, if it be intended to try the effects of boiling water: so that if the hand be dipped into ether, and then into boiling water, the effect will be a sensation of coolness and not of heat.

Ingenious, however, as the explanation of M. Boutigny undoubtedly is, it requires the admission of a new property in matter, and as all hypotheses based on such an assumption require to be closely scrutinized, the doubts of M. Person merit attention, and his explanation careful consideration. M. Person begins by reject-

ing the supposed spheroidal condition, and the consequent repulsive action of caloric at sensible distances, and explains the phenomena thus: when a fluid is projected on a highly heated surface a portion of vapour is immediately formed, which, by its elastic tension, separates the rest of the fluid from the heated body; and in like manner, when the moist hand is plunged into the molten metal a film of vapour is formed between the metal and the hand, or rather between the metal and the remaining portion of the fluid on the hand, and as the latter is a slow conductor of heat, some time must elapse before the hand will itself be seriously affected by it. Whilst, therefore, a theory is yet in uncertainty, it seems scarcely wise to refer to it for an explanation of great natural phenomena; but under any view of it may there not be a doubt as to its application in the manner proposed by Mr. M'Adam? How could the interior of the crust have been brought into the supposed spheroidal state, and a separating film of vaporized mineral matter generated on M. Boutigny's principles, since it is reasonable to suppose that originally the crust and nucleus were only continuous parts of one mass?

How could water pass through such an atmosphere of vaporized mineral matter without being reduced to vapour long before it came in contact with the solid nucleus?

Putting aside, however, the conditions of an independent crust, with an inner surface in the spheroidal state, and a separating atmosphere of vaporized mineral matter, as resting solely on hypothesis, the properties of matter in a fluid state, as exhibited by M. Boutigny, may be useful in connecting steam with terrestrial disturbances, as it does appear possible that a column of water penetrating by channels in the superficial crust, might come in contact with a portion of the nucleus, at a vastly higher temperature than its boiling point, when vapour would be generated of sufficient tension to keep the rest of the column free from actual contact. This state of things would continue until the vapour, having gradually increased in quantity and in tension, had acquired a force sufficient either to burst the retaining crust, or to force up the column of water.

The phenomena of physical geology are invested with so many difficulties that their investigators have hitherto been few,

and there has been a disinclination on the part of many eminent geologists to admit them as a branch of the science; but surely no one who looks at the subject in its grandest point of view can adopt such opinion, or refrain from attempting to unravel the difficult as well as the easy problems of creation. I need here only refer to the labours of Mr. Hopkins as a proof of what may be done in such an inquiry, and I congratulate the Society that one of its own members has been willing to pursue so arduous an investigation. In attempting it Mr. Barrington has necessarily been obliged to assume some basis of calculation, and then to ascertain how far the facts before him were reconcilable with it; he has thus assumed that lateral pressure, or a disturbing force acting laterally, has been the cause of contortions in strata, and then, by mathematical analysis, demonstrated that such pressure—that, for example, which would accompany the intrusion of large quantities of liquid matter amongst the more solid strata—is sufficient to produce, and would produce, contortions of the description and forms actually observed in the strata of the earth. In this investigation Mr. Barrington assumes, that the stratum or bed acted upon is always slightly bent, or in other words, never in the same mathematical plane as the force acting upon it; and this assumption may be at once admitted, as in nature the beds can never be in the same plane as the lateral force acting upon them, for if we suppose, as is most probable, that the pressure is the result of a forcible intrusion of igneous mineral matter amongst them, the necessary rupture of the beds must be accompanied by a disturbance of their original position, even if it were supposed to have been coincident with the plane in which the pressure resulting from that intrusion acted.

Mr. Barrington on this hypothesis determines two formulæ, the one giving the amount of normal pressure exerted against the curve of the bed or stratum, at any one point which is proportional to the force applied directly and inversely as the radius of curvature at the point; and the other the amount of the force. It is evident then, that if some absolute values could be determined of the amount of the original pressure and of the resistances, the precise bends or curves of the strata might be also determined. This, however, is not here attempted, but presuming certain conditions of yielding, Mr. Barrington shows the several modifications of the

curve which would result from them. In the first instance this is taken as a single curve, but if the force be considered as transmitted on, without diminution from friction, a second, and a third, and indeed a series of curves would follow. The friction, however, of the beds must be very great, and the compressive force will be gradually diminished by it, so that the magnitude of the curves or contortions will also diminish. When the strata once begin to move and assume the curvilinear shape they will continue to bend if the pressure continue and be confined to this portion of the strata, until fracture takes place, and no second bend would be formed until then; but if the friction has not prevented the transmission of the force so as to act on the more advanced parts of the stratum, a second and a third bend may begin to be formed simultaneously with the first move of the original bend, and as each of these may proceed to its point of yielding or fracture, a series of broken curves may be formed. There can be little doubt that the results here stated are quite in harmony with the phenomena of contorted stratification; and it will be well also to bear in mind that there is no necessity for supposing that the strata we now see so singularly contorted were in their present state of induration, and even crystallization, at the time of their disturbance. On the contrary, it is far more probable that they were then beds of loosely aggregated materials, and after contortion were reduced by metamorphic action to their present mineral condition. I have said that Mr. Barrington was obliged to assume the existence of lateral pressure, and I have suggested as one, at least, of its proximate causes, the intrusion of melted mineral matter amongst the strata of the earth, accompanied by rupture or disturbance of its crust.

That such intrusions as exhibited by volcanic phenomena have taken place at all geological ages, and still continue to occur, must I think be now admitted by every geologist. Professor Oldham refers those of Wexford to the Silurian epoch. In his notice of the Wexford geology, which was his last contribution to our Society, he states, that "the slate rocks, east of the town of Wexford, towards Carnsore Point, belong to the middle portion of the series, and are not, as shown in previous maps, Cambrian, or the lowest beds. This portion is characterized by a great abundance

of trappean rocks, volcanic ashes, breccias, &c., accompanied by many fossiliferous beds."

In my own brief Paper I have quoted an example from the carboniferous slates of Bantry Bay, in which the intrusion of igneous rocks is exhibited on the shore, as well as the most remarkable contortions of the strata at Whiddy Island opposite to it.

Some of the basaltic eruptions of the North of Ireland were of the liassic, others of the cretaceous, and others probably of the tertiary epochs. The disturbances described by Sir R. Murchison in his Paper* on the Vents of Hot Vapour in Tuscany, have occurred in parallel lines, and were accompanied by erupted matter, at successive epochs, "and with the simultaneous production of great divergent elevations, in Italy and the Alps, even after the deposit of the nummulite or eocene formation." And again, M. Rochet d'Hericourt describes that portion of Abyssinia which lies between Massenah and the Red Sea, as in a continued course of elevation, a conclusion which he establishes from many facts, such as the drying up of once abundant springs and numerous proofs of volcanic action in hot springs, ancient craters, &c.†

The connexion of the eruption of igneous rocks, or of mineral matter in a fluid or semi-fluid state, with the disturbance of the earth's crust, and the contortions of its strata, is so important an element in geological reasoning, that it is desirable to dwell for a few moments upon it. Doubtless the expectation of finding erupted igneous rocks always at the point where the contortions of the strata are at their maximum, has led to frequent disappointment; but if it he considered that on the principles set forth in Mr. Barrington's Paper, the impulsive force exercised by the igneous matter in its course upwards, would act laterally in a diagonal manner on the superficial strata, it will be easy to conceive that the yielding beds would be forced laterally forwards and upwards, and by the contorting consequent on a resistance to the upward movement from the superincumbent weight, would be packed into a much less horizontal space than that which they occupied previously. It is therefore in the axis of disturbance, whether found in an anticlinal mountain valley, or in a plane at the outcropping edges of the disturbed strata, that

* Geol. Journal, Nov. 1850.

† Comptes Rendus, Feb. 1850.

evidences of eruption should be sought. In Bantry Bay I have pointed out examples of the intrusion of igneous rocks amongst the metamorphosed schists of the shore, whilst the great contortions are in Whiddy Island, distant from it about a mile, the actual focus of disturbance being probably under the intervening channel.

In Sir Roderick Murchison's Paper before referred to, that able observer has shown that the result of igneous eruption has been in the case of the Alps and Apennines, divergent lines of simultaneous disturbance.—"In the chief range of the Swiss and Austrian Alps, the greatest changes of metamorphosis, elevation, depression, and contortion have been determined upon lines having on the whole an E.N.E. and W.S.E. direction, whilst in the Apennines the same changes have occurred at the same periods in linear bands trending generally from N.W. to S.E., and bearing round to a meridian strike as they approach the direction of the ancient and palæozoic rocks of Corsica and Sardinia."

The centre of disturbance Sir R. Murchison places to the N.W. of Genoa, from which region of chief eruption, "trends, from N.W. to S.E., the serpentine bosses of the Apennines, between Bologna and Florence, which, though divergent from the line of the Apuan Alps and Tuscan Maremma, are exactly coincident with the major axis of the Apennines, or great back-bone of Italy, the culminating point of which, as at the Gran Sasso d'Italia, 9,530 feet above the sea, are composed of eocene and cretaceous rocks reposing on jurassic." In endeavouring to trace back these disturbances to the earliest epochs, it appears that, in the line of Sardinia and Corsica, there is a meridian chain of ancient crystalline and silurian rocks, overlaid by a coal formation, and, therefore, "that in that line, as well as in the line of the Alps, the later serpentinous eruption had found its issue along a line of fracture coincident with the direction which had been impressed upon these lands at a very remote period, or with the direction of a primeval coast, on which were found strata containing palæozoic fossils. The peculiar igneous rocks which have in this case been the disturbing agents, are the gabbro rosso, a red felspathic rock, with a concretionary and variolitic structure, resembling some of our amygdaloids, and serpentine;

and whilst in the Alps no trace of subaerial volcano has been found, and the youngest igneous rocks appear to have been those which traverse the older tertiary deposit, in the Apennines there are proofs of copious volcanic eruptions, extending in Vesuvius up to the existing epoch; so that Sir R. Murchison comes to the important conclusion that "subterranean igneous forces develop their action at successive epochs along the same established bands of active change in the crust of the globe." In determining, however, the exact limits of successive epochs of disturbance, there is a source of error which appears to have been overlooked. It is, for example, generally assumed that the disturbance must have taken place subsequent to the epoch of the broken and inclined strata, and anterior to the overlying horizontal strata, but this does not appear an absolutely necessary consequence, as it is highly probable that in many cases the contortions may not have extended into the uppermost strata, but have ceased at that point where the weight of the superincumbent mass was not sufficient to prevent its yielding to the pressure from below and moving upwards. In such a case as this the unconformable position of the overlying strata would be no proof that the disturbance which had contorted and tilted up the beds under them was in date anterior to their deposition; and, at the same time, it would be unnecessary to seek for a second depression or subsidence to account for their deposition. It is by no means my intention to refer all unconformable stratification to the cause I have here pointed out, although I think that some examples may be best explained by it, as well as many of the phenomena of denudation in which portions of the unconformably overlying strata are left as caps on elevated and exposed crests, whilst other portions either remain in the valleys below or have been swept away.

That remarkable dependence of the form of a palæozoic coast on a line of intrusion of igneous matter, at a still more remote epoch noticed by Sir R. Murchison in the paper above referred to is generalized by M. Agassiz in his recent work on America.* Having first laid down as an established fact that the form and peculiarities

* Lake Superior; its Physical Character, Vegetation, and Animals. Boston: 1850.

of the world's present surface are principally due to the elevation of mountain chains and the rise of extensive tracts from plutonic and volcanic action, he enters on the inquiry whether the subordinate features of a country are also to be ascribed to similar geological phenomena. The lakes of America, he observes, are excavated chiefly between the plutonic masses rising north, and the stratified deposits south of the primitive range; Lake Superior filling a chasm between the northern granitic and metamorphic range, and the oldest beds deposited along their southern slopes in the primitive age of the American continent; Lakes Huron and Michigan filling up cracks which run at right angles with the main northern primitive range, and which owe their origin to the elevation of the chains north of Lake Huron and Lake Superior; whilst Lakes Ontario and Erie run between successive sets of beds of the same great geographical period, or in a manner parallel to the first great depression occupied by Lake Superior. So far the connexion of the form and position of the lakes is with the greater exhibition of disturbing forces, which has resulted in the elevation of mountain chains, the intrusion of plutonic rocks, and the metamorphoses of the disturbed strata into crystalline rocks; but M. Agassiz carries the operation of such forces still further, and explains by it the minor modifications of the coast line of Lake Superior, as even the greatest complications in the outline of the shores can be accounted for by the combinations of dykes intersecting each other in different directions. These dykes he found arranged in different systems, each having its peculiar direction and peculiar mineral composition—a fact of very great interest. The dykes, which run north and south, forming several inlets, and intersecting the large Island of St. Ignace, consist of very hard, tough, unalterable hornblende trap, of a crystalline aspect and greyish colour: those which run east and west, determining the direction of a considerable portion of the coast, which it sometimes intersects in parallel lines, consist mostly of a greenish trap extensively injected with epidote; and those which determine the form of the north-eastern coast run N.N.E. to S.S.W., and consist of a pitchstone trap, like black glass, which, though externally very hard, readily decomposes, and gives rise to deep coves, narrow inlets, and small caves,

highly characteristic and picturesque. The north-western shore, which generally trends from N.E. to S.W., is greatly modified by the intrusion of igneous matter, as exhibited in three systems of dykes which, intersecting each other at acute angles, give rise to a similar disposition of the coast line. One of these is a black trap, and runs nearly N.E. and S.W.; another, running exactly N.E. and S.W., is rich in copper ores, and full of spathic veins; whilst the third runs E.N.E., and is of a light grey colour, without epidotic injections. In addition, therefore, to probably two other less-marked systems, there are six distinct systems of dykes, which contribute mainly to the formation of the northern shore of Lake Superior, viz:—No. 1, running E. and W.; No. 2, N. 80° W.; No. 3, due N. and S.; No. 4, N. 80° E.; No. 5, E. 30′ N.; No. 6, E. 45° N.: and it is by these six distinct systems of dykes, with peculiar characteristic trap, which form ridges parallel in the same system, but varying in different angles between the different systems, that the northern shores of Lake Superior have been intersected, and the whole tract of rock over the space which is now filled by the lake so cut up as to have destroyed its continuity. Depressions were thus produced, and an excavation gradually created which now forms the lake; and this process of intersection by the injection at successive periods of different materials, which has given to the lake its present outline, has evidently modified, at various epochs, the relative level of sea and land, materially affecting the deposition of its shore drift, and producing the successive amphitheatric terraces which border at various heights its shores. This repetition of successive eruptions of igneous matter in the same district is also stated by M. Rozet, in his paper on the Pyrenees,* where he describes two granitic eruptions—the one anterior to the transition (*id est*, Cambrian and Silurian) epochs, the other posterior to the cretaceous epoch, and mentions some curious facts illustrative of the actual condition of the granite at the time of eruption—namely, whilst fragments, more or less rounded, of granite are found imbedded in the arenacious strata of the transition epoch which overlie the greater masses of the plutonic

* Comptes Rendus. December, 1850.

rock—an example remarkably in accordance with the one afforded by the fragments of granite in the neighbourhood of Dublin—large blocks of the cretaceous limestone are found imbedded in the granite of the second eruption, as if that rock, in a semi-fluid state, had enveloped them.

It is certainly impossible to study such cases, and they might be multiplied, without agreeing with Sir R. Murchison that the outpouring of liquified mineral matter, and the disturbance of the strata, have taken place at successive epochs in lines differing but slightly in direction. In that conclusion, however, both Sir R. Murchison and Professor Agassiz have been anticipated by that most philosophical geologist, M. Elie de Beaumont, who, in pointing out nearly twenty years ago that systems of mountains of different ages have sometimes very nearly the same directions, applied to this fact the expressive term "periodic" return of directions, and understood by it that systems of mountains were not disposed by chance, as regards their relation to each other, on the surface of the earth, but were arranged in conformity with some definite law by which Nature, in producing them, was constrained to return, after certain intervals, nearly into the same directions or lines of operation.

Since M. Elie de Beaumont advanced this important proposition, and first explained his great theory of a definite system of elevations corresponding to successive geological epochs, and manifested in certain mountain chains, great information has been continually acquiring, and yet there has been little occasion even to modify the views of this author. M. de Beaumont considers the relative ages of twenty systems of mountains to have been determined with tolerable precision; namely, those of La Vendée, of Finistère, of Longmynd, of Morbihan, of Hundsrück, of the Ballons, of Forez, of the North of England, of the Low Countries, of the Rhine, of Thüringerwald, of the Côte d'Or, of Mont Visé, of the Pyrenees, of Tatra, of Sancerrois, of the western Alps, of the principal Alps, and of Ténare; and adds to them the system of Verona, the age of which, though less ancient than the lower chalk, is not accurately determined. M. Durocher has also proposed several other new systems which he has observed in Scan-

dinavia. The object of M. de Beaumont in his later inquiries* is, to ascertain whether those several systems of mountain chains, each of which is represented by a great circle of the earth oriented at some point of its curve—as, for example, that of the Rhine at Strasburg, where its direction is N. 21° E.—can be represented by any definite or geometric arrangement of intersecting planes. Considering, then, the 21 great circles as mountain systems, which have been accurately determined, each of them, if prolonged, would cut the other twenty in two different and opposite points, so as to produce altogether 420 different angles, or 210 angles in one hemisphere. These angles M. de Beaumont first determined from the known orientation of the several great circles or systems of mountains, and then plotting them on paper he found that they grouped themselves within very limited spaces, leaving large blanks between, and were thus entirely in conformity with natural appearances. The object was now to represent this fact by some definite geometric arrangement, so as to ascertain whether the planes adopted theoretically could by these intersections produce the angles which had been observed. After several unsuccessful trials, M. de Beaumont considered the results of the intersections of fifteen great circles, cutting each other in fives, at angles of thirty-six degrees, and dividing the surface of the sphere into one hundred and twenty rectangle scalene triangles, equal in surface and symmetrical in pairs, which may either be adjusted into thirty lozenge-shaped figures, twenty equilateral triangles, or twelve regular spherical pentagons, which latter arrangement M. de Beaumont adopted, and calls the resultant division a pentagonal reticulation. The pentagons meet at angles of 36°, 60°, and 90°, so that these angles and 72°, or the double of 36°, are the only angles which this fundamental reticulation affords; and, therefore, would not correspond to the more complicated system of mountains without the systematic introduction of auxiliary circles. To determine this interpolation M. de Beaumont first takes into consideration the intersections at an angle of 90° of the primary great circles of the

* Comptes Rendus. September, 1850.

pentagonal net; and as the three planes of each of the tri-rectangular systems which they produce, may be considered respectively parallel to the six faces of a cube, the centre of which is the centre of the sphere, and as the five cubes thus referred to may be represented by one cube which had turned 180° round each of the diagonals, M. de Beaumont represents the cube in each of its five positions as the nucleus of a regular crystalline system, composed of the faces of the octahedron, rhomboidal dodecahedron, pentagonal dodecahedron, &c., and other forms, which a regular crystalline system comprises. Then, imagining planes drawn through the centre of the sphere parallel to the several faces of the crystalline type, the result is an infinite number of great circles co-ordinated in the sphere with a perfect regularity and symmetry peculiar to the primary pentagonal net. This M. de Beaumont calls the complete pentagonal reticulation. Studying first, then, the combination of the primitive circles with those resulting from planes drawn parallel to the faces of the octahedrons and to those of the rhomboidal dodecahedrons, there are fifty-five circles, the intersections of which produce nearly all the angles which have been observed, at least all superior to 20° or 30°. By the introduction of other circles corresponding to various pentagonal dodecahedrons, trapezohedrons, &c., new combinations are obtained, all of which continue to exhibit the same tendency of grouping themselves in correspondence with the angles, obtained by observation. M. de Beaumont justly observes, that without doubt many new systems of mountains or lines of disturbance have yet to be discovered, and others will, in course of time be produced, so that the geometric exhibition of phenomena still imperfectly known or developed must, of course, be itself imperfect; but he adds, that if the fifteen primitive circles of the pentagonal net be really considered as a just representation of the primitive form of the network of mountain systems all other subsequent systems may be reproduced by introducing into the pentagonal system the auxiliary circles described above, which are, as it were, representatives of the planes of decrement in minerals.

M. de Beaumont illustrated this truly beautiful theory by the tri-rectangled triangle formed by the great circles of the mountain

systems of Tenare, of the principal Alps, and of the volcanic "trainée" of the Andes and Japan, which triangle is composed of one great circle of the fundamental pentagon, and of two circles dependent on rhomboidal dodecahedrons; and he observes, that though much has yet to be done to determine every minute detail, and to fill up the deficiencies of observation, so as to be able to deduce the several lines of systems by the determination of the angle of one pentagon, and the orientation of one great circle, he feels justified in assuming that the principle of symmetry connected with the pentagonal network does actually exist in nature. To explain this arrangement M. de Beaumont refers to the theory of the progressive secular refrigeration of the internal mass of the earth, and shows that the pentagon here takes the place of the hexagon, which is the prevailing form assumed by matter when splitting or cooling into minor masses, as in basalt. The fifteen great circles which divide the sphere into twelve regular pentagons are the lines of least contour, and would be those of easiest fracture, so that if all the corrugations or ridges of the earth had been produced at once, they would have probably conformed to these circles; but the systems of mountains were produced at different times, and the auxiliary circles were, therefore, probably necessary to connect them as intermediate systems with one or other of the fundamental circles. If such be the case we have, as it were, a key to the mode in which nature, since the earth began to cool, has maintained a species of secular harmony in its results. I cannot too strongly recommend to the able mathematicians of our Society a careful study of this theory of M. de Beaumont.

It will be observed that, except in noticing the paper of Mr. Stevenson M'Adam, little reference has been made to the causes of the great phenomena referred to. The basaltic dyke, the lava current, the contortions of rocky strata, the shocks of earthquakes, elevations and depressions of strata, are all effects, sometimes simultaneous, at other times successive, of some one or more great causes. Whilst, however, these great geological facts cannot be classed with ultimate causes, they are often secondary or proximate causes; and there is a tendency occasionally in some to produce the others. It is thus that the forcible intrusion of

molten igneous matter, as exhibited in dykes, &c., may have produced, as we have already observed, contortions of strata; and the rending of the crust of the earth, which accompanied such intrusion, may, in like manner, have originated the earthquake, which, in the progress of its shock, or of the earth-wave, became subsequently a proximate cause of elevation and subsidence. The phenomena of earthquakes have, from their close connexion with other geological phenomena, excited renewed interest and attention amongst geologists; and we are indebted to our member and late president, Mr. Robert Mallet, for a very learned Report on the subject,* from which I shall deduce some few useful remarks. Mr. Mallet commences his Report with a careful investigation of the history of his subject, and adopts, as the basis of his own propositions, the theory of Dr. Young and Gay Lussac, whose words he quotes. Gay Lussac states: "An earthquake is, as Dr. Young has well said, analogous to an undulation of the air, and is a very powerful sonorous wave excited in the mass of the earth by some disturbing cause, and which would propagate itself with the same velocity as sound;" and having illustrated the manner in which all the particles of a solid mass may be thus shaken by a reference to the shaking of large buildings on the passage of a waggon over the pavement, and other examples, adds—"In a word, earthquakes are no more than the propagation through the mass of the earth of a commotion, which, if not interrupted by cavities, would be extended proportionately further, as the earth itself is more homogeneous."

Mr. Mallet developes this idea of that great philosopher Dr. Young, and of the admirable French chemist—to both of whom he ascribes the highest praise—in the fullest manner, and supports and illustrates it by a mass of facts and arguments. The most important of his propositions are these:—The shock or earth-wave is a true undulation of the solid crust of the earth. The earth-wave or shock has in all cases a true wave form upon the surface of the earth, and when its direction of translation is *quam proxime* horizontally along the earth's surface, the crest of

* First Report on the Facts of Earthquake Phenomena: being Part of Report of the British Association for the Advancement of Science. 1850.

the wave advances along a given line, and parallel to itself. The earth-wave or shock is a motion of great velocity, and occurring during a very short moment of time at any given spot. The motion of translation of the earth-wave or shock is rectilinear and not curvilinear. The direction of translation of the earth-wave or shock varies from vertically upwards to horizontally, or nearly horizontally, in any azimuth. The earth-wave or shock has determined dimensions in height and breadth, or in altitude and in amplitude, and these are dependent upon the force of the original impulse, the nature of the materials through which it passes, and the distance it has travelled. The direction and velocity of translation of the earth-wave or shock change occasionally in passing from the boundaries of one formation to those of another. The time of transit of the sound-wave (which frequently, not always, accompanies the earth-wave) will manifestly differ, whether it reach the ear through the sea or through the solid land; in the former case its rate will be about 4,700 feet per second, if received through air about 1,140, and if through rocks or formations as follows:—

Lias Limestone, . . .	3,640 per second,
Coal Measure Sandstone, .	5,248 ,,
Oolite, ...	5,723 ,,
Primary Limestone, . .	6,696 ,,
Carboniferous Do., . .	7,705 ,,
Hard Slates, ...	12,757 ,,

For granite and igneous rocks there are as yet no data, but the rate will be greater than in any of the preceding.

These propositions and experimental results are of the highest importance, and will, doubtless, when combined with further experiments on the passage of the wave through variously compressible substances, remove much of the obscurity which yet hangs over this great subject.

Mr. Mallet carefully and properly separates the phenomena of earthquakes, which he considers only part of the effects of some great disturbing force, from other effects, such as elevation and depression, which may either proceed from a similar or still more powerful force; and considers the earthquake as generally tend-

ing rather to depress and break up than to elevate the crust of the earth. In this view he is, doubtless, in the main correct, as the very idea of a wave implies undulation, not permanent elevation, of the surface; but, at the same time, this effect must be materially varied in passing through compressible strata, as in that case a certain amount of compression may be attained before the vibration is fully transmitted; and as the compressed stratum may never return to its original bulk, it is not improbable that it may have been squeezed partly upwards, and have continued after the shock elevated. In like manner the partial yielding of compressible strata may produce nearly the same effect on the more solid rock, as a sudden cessation of the vibrating material at the edge of a precipice has been shown to do, and be the cause of fractures or chasms. If so, such cracks or chasms will often explain the local structure of the crust of the earth when hidden from the eye by superficial deposits. May not, indeed, the whole progressive impetus of the wave be absorbed in this compressing and contorting action, and the undulation be at last brought to rest? I have thought it necessary to dwell so long on this interesting portion of our fellow-member's able Report, as it specially relates to the facts of earthquakes, and comprises many examples of their secondary effects, which are particularly valuable to the geological student; but the author does not confine himself to the detail of facts, as he endeavours also to account for them, and to give some reasonable account of their production. In this he concurs with Mr. Stevenson M'Adam, and seeks his explanation in the properties of steam. "In general," he says, "the average of numerous narratives seems to give from three or four to fifteen seconds as the duration of the great shocks, from two to ten or fifteen minutes for that of the powerful vibratory shakings, and an unlimited or, at least, uncertain time for slighter tremors afterwards. What sort of impulse then will be competent to account for this general order of succession? I believe it will be found either in the sudden bringing into contact, under pressure, of large ignited surfaces with cold water, or the blowing through and into cold water of volumes of steam under pressure, and this steam suddenly condensed therein." And again—"Briefly, then,

it seems to me that, however modified, the immediate impulses producing earth-waves of shock are due—

"1. To the sudden formation of steam from water previously in a state of repulsion from the heating surfaces (spheroidal state), and which may or may not be again suddenly condensed under pressure of sea water.

"2. To the evolution of steam through fissures, and its irregular and per saltum condensation under pressure of sea water.

"3. To great fractures and dislocations in the rocky crust, suddenly produced by pressure acting on it from beneath or in any other direction.

"4. Occasionally, but rarely, to the recoil from mighty explosive effects of volcanic foci, as when a mass of rock weighing 200 tons was shot from the crater of Cotopaxi to the [distance of nine miles (Humboldt); or when nearly one-half of the crater of Vesuvius was blown away."

I have already expressed my doubts of the expediency of appealing to a disputed property of matter in explanation of earthquake or other phenomena; but it is necessary to add some few words in reference to Mr. Mallet's mode of treating the subject. "When an irruption," Mr. Mallet observes, "of igneous matter takes place beneath the sea bottom, the first action must be to open up large clefts or fissures in its rocky material, or to lift and remove its incoherent portions, such as sand, gravel, &c. The first portions of water that gain access thus to the ignited surfaces, repelled by their heat, are brought into that peculiar state which Boutigny and others have called spheroidal. While in this condition their intestine motion may be great, but little steam is generated; and while this is the case no impulses will ever be conveyed to a distance, but only those tremblings or vibrations which precede the shock," &c. Before proceeding further it is right to ask by what force the irruption of igneous matter was produced, and how it could take place without some *previous* rupture of the earth's crust. But whether the rupture were previous to or simultaneous with the irruption, it is evident that the rending of the rocky materials of the sea-bottom must be attended with a jar or vibration through the solid crust quite sufficient to account for an earthquake or earth-wave, even though it may be followed up by

other shocks and vibrations from other causes, so that the third cause cited would always precede the others. Mr. Mallet proceeds—"But no sooner has the surface of lava become cooled to the point at which repulsion ceases, and the water altering its state comes into close contact with the heating surfaces, than a vast volume of steam is evolved explosively, and, blown off into the deep and cold water of the sea, is as instantly condensed; and thus a blow or impulse of the most tremendous sort is given at the volcanic focus, and being transferred outwardly in all directions, is transmitted as the earthquake shock." I fear, as I have stated in my remarks on the views of Mr. Stevenson M'Adam, that this explanation cannot be admitted without a much more accurate knowledge of the property of water in the spheroidal state than is at present possessed: and here also, as in the previous case, the mode of bringing such property into action seems obscure. Is it, for instance, with matter or lava which has been erupted that the water comes into contact, or is it with the molten matter within the volcanic focus? If with the lava erupted and spread out on the sea bottom, how can such results follow as those described?—or even were they possible, would not the sea-wave precede the earth-wave, and greatly exceed anything of which there is experience or evidence? If, on the other hand, the water be supposed to penetrate into the volcanic focus, and to come in contact with the molten matter within it, it is difficult to understand that diminution of temperature which is said to result in a cessation of the supposed repulsive action of caloric. If the phenomena attributed by M. de Boutigny to bodies in the spheroidal state be due to the repulsion of caloric, that power is exercised through a very great range of temperature, as, for example, it acts both when the damp or moistened hand is plunged into a bath of molten iron at a very high temperature, and into a vessel of boiling water at a comparatively low one. In the latter case the hand will be partially protected when moistened with water only, though there will be a sensation of heat; but when moistened with ether there will be a sensation of cold. Something more, therefore, than the mere abstract repulsive action of caloric is necessary to explain the effects referred to by Mr. Mallet on this theory; nor do I see in any of the experi-

ments evidence that such repulsive force, if existing, is of such magnitude as would resist the pressure of immense columns of water, and keep the fluid at a distance sufficient to stop, or at least to retard, for a considerable time, the transmission of heat. The views of M. Person on the subject I have already stated; and I can only repeat that it will be wise to refrain from adopting, as an explanation of some of the grand phenomena of the earth, a theory deduced from experiments on matter, conducted in comparatively a micrometric manner. How, then, are we to explain the convulsive shock of the earthquake, or the forcible protrusion of melted stony matter in the basaltic dyke, or the lava stream? The earthquake, I ascribe, with Mr. Mallet, to the rending asunder of the rocky crust of the earth. But by what force was that crust thus torn asunder, and streams of mineral matter forced through it? Mr. Mallet appears to adopt electric agency as the great final cause which has produced such results. "Thus, then," he says, "ignorant as we are of all within the outer surface or skin of our globe, we are compelled to see the close connexion of these mighty heating powers, in which ignition is present on the vastest scale, *yet without combustion*, with the forces of terrestrial electricity and magnetism—forces which are those alone that, within the range of our observation, are mutually convertible, and both convertible into heat. Currents of both we know are ever passing, with variable activity, through enormous volumes of the earth's crust, the different parts of which possess very different conducting powers. Can it be that these currents, constrained to pass through narrow and bad conductors, at vast depths in some formations, ignite them in their progress? Will it be found that the great lines of volcanic activity (as dreamed of by Bylandt) are in some way connected with those of terrestrial magnetism?—are possibly normals to the surface curves of equal magnetic intensity? A glance at one of Gauss's magnetic maps, and at another of the great bands of active volcanoes on our planet, almost forces the mind into such conjectures." It has long been felt by physical geologists that those great fundamental forces which, under the names of electric and magnetic fluids, can be traced throughout the limits of our earth's sphere, must share with gravitation in the regulation of

its material phenomena; but as yet the difficulty of connecting the known with the unknown, the experiment made in the laboratory with the great cosmical effects which the crust of the earth exhibits, has been so great that little advance has been made, excepting in the case of mineral veins, beyond conjecture. The time, however, is fast approaching when decided conclusions will be drawn from facts, and electricity and magnetism be either admitted as great cosmical forces, or finally rejected. I fully anticipate, as I have on previous occasions conjectured, that the result will be affirmative; and it appears to me probable that a clue will be found to unravel the mystery in the newly discovered form of these forces, which has been designated diamagnetism. Now, indeed, that it is known that all bodies are affected by magnetism, though in two different ways—one class being attracted and the other repelled by the magnet—there seems little reason to doubt that the stability of the earth depends on the due balance between bodies in these opposite states. M. Plücker* observes, that when a body is formed of several elements merely combined together mechanically, its magnetism is the resultant or sum of the individual magnetisms of all the elements—a sum in which diamagnetism is represented as negative; and it may, therefore, be readily understood how much the magnetic condition may vary in sedimentary deposits, and what great disturbance of the magnetic equilibrium may be effected by the removal of detritic matter from one part of the earth, and its deposition and consolidation in another. The effects also of heat are very striking in modifying the magnetic force, the diminution being rapid from 32° to 500° of Fahrenheit, and then very slow, and still more sudden in diamagnetism, as the limit of rapid change is about 450° of Fahrenheit. Changes of temperature, therefore, may, in like manner, produce great disturbance in the magnetic equilibrium of bodies. M. Plücker's observations on the action of magnetism in the formation of crystals, and on the indication of terrestrial magnetism by crystals, are more especially deserving of attention. Having ascertained, by experiments on cyanite, augite, and oxide of tin, that the crystals of those minerals were under

* Sur le Magnetisme et Diamagnetisme; Annales de Chimie. June, 1850.

the magnetic influence of the earth, and that the polarity manifested was in direction co-incident with the mean line of the optical axis, he naturally inferred that a magnetic force might have been exercised in the formation of the crystals, or that the same force which exercises a directing power over the crystal when formed, may have also acted on the molecules during the process of aggregation, and caused them to take that position with respect to the poles as would correspond to that which the formed crystal would take when freely suspended. In this manner when melted bismuth is allowed to cool between the poles of a magnet, the particles assume such a position as to manifest distinct polarity, the principal plane of cleavage being perpendicular to the line connecting the poles. M. Plücker, therefore, asks, as a resulting question—"Has terrestrial magnetism had any influence on the formation of those crystalline masses which occur in the bosom of the earth?" and in replying to it, it is scarcely necessary to do more than to point to the great phenomena of stratification and of cleavage, as they are displayed in the crystalline stratified rocks. But whilst we are disposed to adopt electric and magnetic forces as great ultimate causes of modification and disturbance in the earth's crust, it would be neither prudent nor philosophic to exclude other causes when known to produce effects analogous to those we observe in nature. The sudden combination of oxygen, chlorine, and iodine with the metallic bases of the alkalis, is one of these, and though now unpopular ought not to be entirely rejected. When, indeed, the great quantity of chloride of sodium which exists in the sea and in salt-bearing deposits is considered, it does seem more than probable that much of it has been formed by such direct combination, attended by the evolution of much heat, and consequent physical disturbance. This idea is further supported by the very general diffusion of iodine in combination with potassium, both in fresh and sea water, and in fresh water and marine plants, as it is only natural to consider that the present condition of the sea is only a great final result, the formation of the salts it contains having been original, and consequent on the sudden combination of their elements.

But there is another theory which has obtained almost general

support, namely, the force exercised by the crust of the earth in its gradual contraction or cooling upon the liquid nucleus below it. It is on this theory assumed that the earth has been in an igneous fluid state; but there are two modes of considering its present state. In the one a consolidated crust is supposed to rest on a liquid nucleus; in the other, as advocated by M. Constant Prevost, cooling is supposed to have commenced at the centre, and the result to have been a solid nucleus separated from the congelated crust by an igneous liquid annulus. The congelated crust on contracting compresses the liquid matter below it, until the cohesive force of the crust yields to the pressure, and it gives way or cracks, when the liquid matter below is forced up, whilst the jar or vibration in the rending of the strata produces an earthquake or earth-wave. M. Prevost, in his fourth and fifth propositions, expresses distinctly this idea:—"At the same time that incandescent fluid matter, penetrating the cracks formed in the primitive crust by its contraction, has been either lodged in its interior, or poured out irregularly on its surface, and there on cooling become solid, detritic matter held in solution by the water or atmosphere has been precipitated, and formed stratified deposits, which have become consolidated by pressure, desiccation, and crystallization, giving rise to two classes of effects—the one ascribed to an internal plutonic or igneous agency; the other to a neptunian or aqueous agency—which either alternately or simultaneously have concurred in the formation, the dislocation, and degradation of the soil, just as volcanoes on the one hand, and the sea on the other, now synchronously and incessantly modify the state of the earth's surface. The undulations, foldings, fractures, depressions, and elevations, which both stratified and massive rocks have experienced—the shocks and dislocations consequent on earthquakes—the identity of composition of the substances poured out by volcanoes at all parts of the globe—cannot be explained with the same ease on any other theory than that which admits that the external crust or envelope of the earth rests on a zone of matter still soft and probably incandescent, whence have proceeded, at successive epochs, granites, porphyries, trachytes, basalts, and lavas."* M. Faye, in

* Comptes Rendus. September, 1850.

a letter to M. Constant Prevost, which was read before the French Academy, admits most fully the philosophical character of the fundamental theorems of M. Prevost, whilst he endeavours to remove the difficulty which the latter felt in regard to the formation of a crust on the earth. M. Prevost recognises the existence of the crust, though he appears to doubt the possibility of its formation on the surface of a fluid body, which he conceives would be so frequently disturbed by tides, as to prevent any steady settlement or continuity of a crust. He therefore infers that the earth cooled from the centre outwards, as would be the case in a perfect fluid; but this M. Faye does not admit, as there is no experience of the effect of tides on a viscous fluid such as the molten earth must have been when on the point of solidifying: nor, indeed, has their amount or character under such circumstances been investigated. M. Faye also observes, that the tidal wave does not prevent the formation of ice on tidal rivers, although the ice rises and falls with the tide, and that the density of the beds constituting the crust of the earth being less than the mean density, a considerable increase of density by contraction might be possible, without permitting any portion of the upper beds to sink and descend into the liquid portion below.*

This observation of M. Faye, respecting the coating of water by ice, leads me, from its analogical bearing, to close my remarks on this important subject by a reference to the theory of the Messrs. Rogers of Philadelphia. These eminent geologists have ascribed the phenomena of earthquakes and the contortions of strata to the movement of a wave on the liquid nucleus of the earth. It appears to me that this theory has been misunderstood, as I do not conceive, with Mr. Mallet, that they intended to represent the foldings of strata as actually waves of the solid crust, but merely as results of the compressing action of the semi-fluid wave moving under it. If, indeed, on contraction the solid crust was fractured, and by the consequent reaction the surface of the fluid nucleus was put into motion, the effect of the passing wave would be in proportion to the compressibility of the substances on which it acted, which as they yielded would be compressed and folded, as by any other lateral force, whilst from

* Comptes Rendus. October, 1850.

their imperfect elasticity they would retain nearly the position and form they had been forced to assume.

What has been here said will, it is hoped, be a useful commentary on a still obscure though deeply interesting portion of geological science; but in respect to the other great phenomena connected with those internal forces by which, in part at least, the disturbances and contortions of strata have been effected, it has always appeared to me that we must trace them up to their very cradle, in order to understand them clearly, and, therefore, that they can only be fully illustrated by a correct analysis of rocks. It is not enough to talk of metamorphic change, or to assume that a change such as that of a limestone into an essentially quartzose rock is possible, without previously appealing to the results of careful chemical inquiry. Without such chemical evidence the possibility of any change which implies an elementary change ought not to be admitted. Whilst the matter of rocks remains in a loose state, it is possible that both a separation and an arrangement of particles may take place within it; and that silica, alumina, and other elements may be thrown into definite positions; but when a rock has assumed a solid and even crystalline constitution such changes should be received only with great caution, and after rigorous examination.

The analysis by the Rev. Mr. Galbraith of some remarkable nodules, which I have described as occurring in the contorted schists of Whiddy Island, is a useful example, as the external aspect of the nodules is more like that of trap than of highly calcareous rocks. In this case there has been, under metamorphic action, a re-arrangement of the molecules, accompanied by a change of physical character, but without a removal of the principal original elements. Mr. Galbraith's analysis gives:—

Carbonate of Lime, ...	86·30
Carbonate of Magnesia, ...	1·04
Carbonate of Manganese, . . .	3·44
Silex, ...	8·21
Water and loss, ...	1·01
	100·00

with traces of iron and alumina, the specific gravity being 2·709. To the presence of silex and manganese must be ascribed the peculiar trap-like appearance of these lenticular masses, which, doubtless, existed in the original strata as ordinary calcareous nodules. It is on account of this evident necessity to elucidate geological phenomena by the direct appeal to the chemist's crucible, that I value the continued exertions of M. Delesse. Of his various recent analyses of rocks, and what may be called rock minerals, such as euphotide, diallage, diorite, &c., I think it specially necessary to point your attention to that of protogyne or talc granite. Three different specimens from separate localities were examined, namely—1. The summit of Mont Blanc; 2. One of the Needles of the Mer-de-Glace; 3. From the Aiguille-du-Dru, which differed materially from the other two, having a gneisose structure and a density of 2·72. The results were as follow:—

	1st Specimen.	2nd Specimen.	3rd Specimen.
Silica, . . .	74·25	72·42	70·75
Alumina, . .	11·58	14·53	—
Oxide of Iron, .	2·41		
Oxide of Manganese,	traces,	traces.	—
Lime, . . .	1·08	1·03	1·08
Magnesia, Potash, and Soda, . . .	10·01	—	—
Water, . . .	0·67	—	0·71
	10·000		

He observes, that in the numerous varieties there are two distinct types: a granitic or highly crystalline granite, such as No. 1, which lies nearest to the axis of the chain, and contains mica, with little talc; and a schistose, which contains much talc; and, in like manner, that these differences are characterised by variations in quantity of silica, which increases on approaching the centre of the chain—a fact which certainly strongly supports the idea that all these rocks are metamorphic. This relation of the characters of the rock to the quantity of silica is also observable in the Vosges, excepting where the upper or outer portion of the rock is in contact with a sandstone—another remarkable evidence

of the probability of metamorphic action, and of the mode of its operation.

The quantity of water in these rocks is remarkably small, and in the more granitic varieties the magnesia, as a silicate, is small in amount, and appears with the silicate of iron to form the colouring matter; protogyne is then a granitic rock, and differs little from some common granites, except that it contains one or two per cent. of oxide of iron and magnesia. Its principal elements are quartz, two felspars—one of which is orthose, the other oligoclase—a mica of two axes, rich in iron, and a variety of talc. It differs from granites of two felspars by the composition of its mica and the presence of talc, for although this mineral is occasionally or accidentally found in granite, it is in protogyne an essential element, extending to nearly the whole formation, and being developed in large quantity. The Pegmatite of the Vosges is actually composed of three minerals—quartz, a felspar of the orthose form, and a silvery mica in which potash, soda, and magnesia are all present, and generally accompanied by tourmaline. The analyses of M. Delesse* are as follow:—

FELSPAR.		MICA.	
Silica,	63·92	Silica,	46·23
Alumina and Oxide of Iron,	20·05	Alumina,	33·03
Oxide of Manganese,	0·30	Per-Oxide of Iron,	3·48
		Manganese,	traces
Magnesia,	0·60	Magnesia,	2·10
Lime,	0·75	Lime,	traces
Potash,	10·41	Potash,	8·87
Soda,	3·10	Soda,	1·45
Loss,	0·41	Water and Fluoride of Silicium	4·12
	99·54		99·28

It will be observed that when to the proportion of silica contained in these minerals be added that of the quartz, which is the most essential constituent, a rock very rich in silica will be

* Annales de Chimie. Jan., 1850.

the result; and this fact should be kept in view when comparing plutonic with truly volcanic rocks, and endeavouring to determine the limits of volcanic action.

The diorite of Port-Jean (Vosges), which appears at Port-Jean, near St. Maurice, in the Vosges, is thus described by M. Delesse.* Hornblende abounds in it, of the variety called actinote; it is very fibrous, and cleaves at an angle of 124 degrees. Its density is 3·059. The felspar is in lamellar crystals, is of a greenish white colour, a greasy lustre, and difficult cleavage. It gives to the rock sometimes a granitoid and sometimes an orbicular structure. It melts more easily than the hornblende. Analysis gives the following composition of the two minerals:—

	HORNBLENDE.	FELSPAR.
Silica,	50·04	53·05
Alumina,	8·95	28·66
Oxide of Chrome,	0·24	—
Prot. Oxide of Iron,	9·59	0·90
Prot. Oxide of Manganese,	0·20	traces
Lime,	11·48	6·37
Magnesia,	18·02	1·51
Soda,	0·81	4·12
Potash,	0·08	2·80
Loss by ignition,	0·59	2·40
	100·00	99·81

And as the chemical composition of the rock itself depends especially upon the proportions of hornblende and felspar which it contains, the analyses of these minerals may be considered the two limits between which the composition of the rock varies. The felspar in composition differs little from that of the Belfahy melaphyr, and is a variety of labradorite, so that in this case labradorite is associated with hornblende, just as it ordinarily is with augite, diallage, and hyperstene—the connexion with igneous rocks being preserved by the felspathic element, and not by the

* Comptes Rendus. 18th February, 1850.

hornblendic. Here also, as in most felspathic rocks to which an igneous origin is ascribed, are present the combined oxides of iron and titanium, and iron pyrites disseminated through the mass; and there are also veins of epidote, quartz, and carbonate of lime. But besides the felspar and hornblende the diorite of Port-Jean contains a felspathic paste, which is not crystalline, is of a greenish colour, a little paler than that of the hornblende, and in composition closely approximates to felspar. This paste, after having been kept for some time in boiling water, slightly effervesces with muriatic acid, but not with acetic acid, and is therefore penetrated by a small quantity of a carbonate of iron and probably also of lime and magnesia. It almost entirely loses its colour by ebullition in muriatic acid, and consequently is not coloured by admixture with hornblende, but probably by either green earth or chlorite. This circumstance of a pervading paste, which preserves within it undecomposed carbonates, suggests a doubt whether the crystalline portion may not have been the result of metamorphic change, rather than of igneous fusion and eruption. Indeed in almost every class of massive rocks there are members which indicate a tendency or power, in erupted rocks, to develop in other rocks with which they are in contact, under pressure, an assimilation to their own characters, provided the necessary elements are present.

The euphotide of Odern,* which is essentially a felspar and diallage rock, also contains carbonates. The diallage closely resembles some varieties of hornblende, and the rock is penetrated by talc in minute radiating lamellœ. Quartz occurs in veins, and sometimes a little carbonate of lime. The euphotide is associated with serpentine, and occurs along the line of contact between the granite and transition slates. Doubtless these peculiarities are also referable to the contact of igneous with stratified rocks, and imply a partial metamorphic action and reaction between the two.

The variolite of the Durance† is a very remarkable rock, as it is composed of a felspathic paste with disseminated globules.

* Delesse; Comptes Rendus. 11th February, 1850.

† Delesse; Comptes Rendus. 10th June, 1850.

The density of the globules is 2·923, and that of the paste 2·806, or below that of basalts. The analyses are—

GLOBULES.		PASTE.	
Silica, . .	56·12	Silica, . .	52·79
Alumina, .	17·40	Alumina, . .	11·76
Oxide of Iron, .	7·79	Oxide of Chrome,	traces
Oxide of Chrome,	0·51	Prot. Ox. of Iron,	11.07
Manganese, .	traces	Prot. Ox. of Mang.	traces
Lime, . .	8·74	Lime, . .	5·90
Magnesia, .	3·41	Magnesia, .	9·01
Soda, . .	3·72	Soda, . .	3·07
Potash, . .	0·24	Potash, . .	1·16
Loss by ignition,	1·93	Loss by ignition,	4·38
	99·86		99·14

It is supposed probable that 2·03 of the above loss may be due to the expulsion of carbonic acid from some of the constituents. Both the globules and the paste are felspathic in composition; and the greater quantity of iron and magnesia in the paste is ascribed to the partial crystallization exhibited in the globules, as in all rocks those two bases are, as it were, rejected or thrown into the mass in the crystallization of felspar. The globular is, in fact, the lowest form of the porphyritic character.

The examination, by M. Delesse, of the serpentine of the Vosges is also highly interesting, as it establishes a specific identity between it and the serpentines of Saxony, and of the Harz, notwithstanding the absence of crystallization. The garnets which are abundant in the serpentine are much more rich in magnesia than the garnets of other rocks, such as mica, slate, &c., and are, therefore, analogous in composition to the serpentine itself. Serpentine is a rock intimately connected with igneous irruptions and metamorphic action. The red porphyry of the ancients has also been analyzed by M. Delesse.* It consists of a felspathic paste with imbedded crystals of felspar, with small crystals of black hornblende and grains of specular iron, quartz

* Annales de Chimie. September, 1850.

being only accidentally present in small quantity. The specific gravity is 2·763; and M. Delesse shows, on comparing it with the porphyry of Rennes, that the hardness of such rocks varies, as well as their densities, with the quantity of silica they contain—the hardness increasing, and the density decreasing—so that the quantity of silica may be estimated approximatively by the density. The specific gravity of the Rennes porphyry is only 2·623, and it contains 77·99 per cent. of silica, whilst the antique porphyry contains 64·00 only.

The development of magnesian garnets in the magnesian paste of the serpentine, and of crystals of felspar in the felspathic paste of the porphyry, seems a result of slow cooling from igneous fusion. Another paper of M. Delesse deserves especial notice, as illustrative of the scrutinizing manner in which he examines rocks, and searches out the secrets of their physical changes.* He had before pointed out the great difference in the magnetic powers of rocks, and had shown that the effect of fusion was sometimes to increase and sometimes to diminish it. In this paper he states, that in rocks of high magnetic power minerals rich in iron are spread through the paste, whilst the minerals found in veins and cavities are comparatively poor in or destitute of iron. Such is the case in serpentines, melaphyres, basalts, lavas, &c. In rocks, on the contrary, possessing only low magnetic power, the minerals of the paste and of the veins are nearly similar as regards their amount of iron, as is the case in hornblende rocks, greenstones, &c.; and again, in granites, syenites, and other granitoid rocks, there is generally no definite paste, and in all cases it has a very low magnetic power. Even here, however, the minerals rich in iron are associated together, such as the lamellœ of black mica, crystals of hornblende, and grains of magnetic iron. Such associations are the result of a general law, and are the more strongly characterised as the rocks have a higher magnetic power. If, then, in amygdaloids, in serpentine, or other rocks of a high magnetic power, the mass be penetrated by solutions containing iron or chrome which are magnetic, and by others containing silica, lime, magnesia, alu-

* Comptes Rendus. December, 1850.

mina, and alkalies, which are diagmagnetic, the magnetic paste will retain or attract the magnetic solutions, and there will be found minerals rich in chrome or iron, and particularly magnetic iron; whilst, at the same time, it will repel the diagmagnetic solutions into fissures or cavities, where will be formed veins or amygdaloid nodules of quartz, carbonate of lime, zeolites, hydro-silicates and hydrocarbonates of magnesia.

"Magnetic and diagmagnetic forces have, therefore, acted an important part in the separation and association of minerals, especially when the latter have been formed by infiltration; and though the forces may be weak, they act constantly on very small portions of matter in solution, which are then in the most favorable conditions for facilitating the effects of attraction and repulsion."

"Even in the hypothesis of an igneous origin for the minerals of rocks, the same explanation will be available, as the magnetic action will then be exercised on matter in a state of igneous fluidity." M. Delesse further observes, that the electric forces are small in comparison with the magnetic, as regards their mineral effects; but it is highly probable, as suggested by Mr. Mallet, that the electric forces have co-operated in the reduction of mineral masses to a necessary degree of fluidity, as experiments have not yet established a direct influence of magnetism on the cohesion of fluidity, but rather the contrary. See the paper by E. Brunner, jun., Poggendorff Annalen, 1850, No. 1.

Such inquiries as these lead the way to a due appreciation of the phenomena connected with the distribution and association both of minerals and metals. In addition, however, to the long-continued action of magnetic and electric forces, ordinary chemical action and reaction have materially assisted in such operations. M. Daubrée* has examined the question in reference to the remarkable association of tin ores with minerals containing fluoric and boracic acids, such as mica, topaz, tourmaline, axinite, &c., which are generally sparingly spread in nature; and has explained it by the action of a volatile fluoride or boride of tin on a silicious mineral, such as felspar. Examples of the result of such reaction are observable at Saint Austle, Cornwall, where the oxide of tin

* Comptes Rendus. April, 1850.

occupies the place or fills up the form of crystals of felspar, every stage of the process being observable in the various degrees of the change. Not being able to use fluorides, M. Daubrée has imitated the supposed natural process by using the volatile perchlorides of tin and of titanium, and obtained, when the vapour came in contact with steam, in porcelain tubes heated to a white heat, crystals of oxide of tin and of titanium or brookite, hydrochloric acid escaping with the decomposition. It was remarked that the point of the tube where the crystals formed was at 572° of Fahrenheit. The chloride of silicium produced in a similar manner crystals of quartz; and it will be readily understood that in the case of a fluoride or boride the fluoric or boracic acid would have combined with the silicium, and produced some one or other of the minerals which usually accompany the oxide of tin in nature. M. Senarmont,* after recapitulating the experiments of Mitscherlich, Berthier, and Ebelmen on the formation, in the dry way, of the fusible minerals which occur in eruptive, and the crystallization even of infusible substances—those of Gay Lussac and Daubrée on the decomposition of volatile chlorides by contact with steam, such as occurs in volcanoes—the precipitation of carbonate of lime in the form of arragonite by M. G. Rose—M. Haidingers' experiments on the formation of dolomite—and M. Becquerels on the effects of long-continued weak electric currents—observes, that even these were probably not the only forces which worked in the laboratory of nature, and that some of them were not always reconcilable with the association observed; for example, the constant union of diaspore and corundum seems inconsistent with the intervention of excessive heat and the ordinary reactions in the dry way. M. Senarmont, therefore, suggests that the actual form of a mineral deposit should be consulted in estimating the mode of its production; and he considers, from such examination, that it is highly probable that many metallic deposits were produced from solutions; and to support this view he explains, by experiment, the mode in which certain carbonates and sulphates may have been formed in the moist way.

Carbonate of magnesia had been formed, by M. Marignac, by

* Annales de Chimie. October, 1850.

the reaction of chloride of magnesium on carbonate of lime; and M. Senarmont obtained it by the double decomposition of neutral carbonate of soda and sulphate of magnesia. At 212° Fahrenheit, and below, if a solution of magnesia in carbonic acid be mixed with chloride of lime, and the quantity of chloride be more than equivalent to the quantity of magnesia in solution, carbonate of lime only is obtained, without a trace of magnesia; whilst at 302°, whether the chloride of lime be more or less than equivalent to the quantity of magnesia in solution, carbonate of magnesia is obtained with scarcely a trace of lime; and M. Senarmont imagines that the precipitation of a mixed carbonate of lime and magnesia, or dolomite, would have taken place at some intermediate temperature. M. Senarmont illustrates, in a similar manner, the formation of carbonate of iron, &c., and then investigates that of sulphurets. The latter, formed in the moist way by double decomposition, are nearly amorphous, and assume the metalloid colour and state only at the points of contact with the glass tube—a curious fact, which shows that their formation in nature must have been gradual and slow, or else that they had been subject to subsequent solution. The deposition of anhydrous oxide of iron of a red colour, so common in various formations, is illustrated by the action and reaction of a solution of perchloride of iron, carbonate of lime, and carbonate of soda, at temperatures varying from 310° to 392°. M. Senarmont having also pointed out that sulphate of lime is precipitated anhydrous from a highly heated fluid, and the varying solubilities of carbonate of soda and chloride of sodium at different temperatures, observes that many of those combinations of minerals which occur so frequently in nature may be thus explained: for example, that waters charged with chlorides of calcium, magnesium, and iron should mix, under certain conditions of temperature and pressure, with waters saturated with carbonate of soda, and containing more or less of sulphate of soda, and the result would be a deposit of magnesian limestones, anhydrites, red oxide of iron, and rock salt. If, then, the great natural solvent water convey the dissolved mineral matter through the mass of the earth, and the magnetic forces operate upon it in its passage, many of those peculiar assemblages which are so striking in the crust of the earth must be directed to distinct points of

deposition, whether in veins or in cavities; and thus we obtain another explanation of that phenomenon, so remarkable in metalliferous deposits.

Mr. Wm. Mallet read a paper on the auriferous district of Wicklow, and described, in detail, the various minerals associated together in the auriferous sand. Although, in part, these minerals had been before noticed, such a succinct description of them, and such accurate identifications, were most interesting and valuable. The association of gold with platinum and tin, and, in other districts, with tellurium, palladium, &c., is one of those mineralogical facts which, though closely connected with the operation of some of the elementary forces which have acted on the earth's crust, cannot be satisfactorily explained. In like manner the auriferous veins have, in all countries where they exist, been found either in plutonic or metamorphic rocks, and principally in the latter, which seem to be the natural or primary habitats of such metals, as well as of some others which are also abundant from probably secondary segregation or deposit in more recent strata; and it may be reasonably inferred that their introduction into the veins was due, in part, to the causes which induced metamorphic change in the rocks containing them, and which were probably in part magnetic.

The gold-bearing strata of Brazil are stated, in Mr. Henwood's memoir on the metalliferous or gold deposits of that country,* to consist of granite, talcose, and clay slates, and a granular rock of quartz and talc, called itacolumite. These are followed by the jacotinga, which is the principal auriferous rock, and is composed, for the most part, of specular iron ore and oxide of manganese, but sometimes contains talc, mica, and quartz. The gold is either disseminated through the rock and in the short unconnected strings and masses in and forming integral parts of the strata, or disposed in veins or in vein-like masses.

The gold of Brazil is sometimes alloyed with palladium, silver, and platinum; sometimes it is mixed with native copper, and sometimes with large quantities of tellurium. The sulphuret of bismuth has also been occasionally found. Crystallized gold is rare, and chiefly occurs in the beds of rivers. Iron ore of the richest

* Mr. John Henwood, F.R.S., F.G.S. Jamieson's Journal, Jan., 1851.

kind is inexhaustible in quantity. The author had never seen a cross-vein, though he was informed by an intelligent German engineer that wide granitic veins traverse the gold vein at Candonga. I have referred to this district as it illustrates the geological connexion of the gold of Wicklow; and in the cross granite veins we have an indication that the phenomena of metamorphic change, and the formation of metalliferous veins were probably closely connected with the protrusion of the rock in which they occur.

Mr. Mallet's analysis gives the proportions of Wicklow gold:—

Gold,	92·32
Silver,	6·17
Iron,	0·78
	99·27

Or neglecting the iron, 8¼ atoms of gold, and 1 atom of silver.

The Californian gold yields, according to the analyses

	of T. Oswald,	of B. D. Henry,
Gold,	90·97	90·01
Silver,	9·03	9·01
Copper,	—	0·86
	100·00	99·88

The Wicklow gold is, therefore, considerably richer than that of California, though resembling it in its constitution.

Of twenty-five minerals, including two varieties of garnet, associated with the gold, Mr. Mallet notices platinum, titanic iron, sulphuret of molybdenum, topaz, zircon, the small manganesian garnets and augite, as new to this locality; and directs especial attention to the great abundance of tinstone, both as seeming to point to the probable existence in the surrounding district of masses of this valuable ore, and as in itself promising to pay for its separation from the sand.

The great interest which has recently been attached to this valuable metal by the discovery of the rich deposits of California, requires some notice of its history, and will justify me in offering a few remarks on the practical bearing of this discovery. Gold,

precious as it is, occurs far more frequently than is usually believed. Mr. Robert Allan, in his Manual of Mineralogy, thus speaks of it:—"Gold is not an uncommon metal; that is to say, there is none, except iron, more universally disseminated, although often in such minute quantities that its presence can only be ascertained after pounding and washing. It occurs both in veins and beds, in nodules, plates, and small crystals, coating the cavities or interspersed in quartz, but more frequently in the sand of rivers, in valleys and plains into which it has been conveyed from the decomposition of auriferous rocks. This is particularly the case in Brazil, Mexico, and Peru, where it is sometimes met with in masses of several pounds weight. In Siberia, too, it occurs in a similar alluvium or sand, in the country eastward of the Ural mountains, where masses of eight, ten, or sixteen pounds have occasionally been discovered. In Transylvania a considerable quantity of gold is obtained from stream works, near Hermannstadt. In the Wicklow mountains of Ireland, and at Leadhills in Scotland, it occurs in alluvial soil, and in many districts of Germany it presents itself under similar circumstances. My father's collection contains a specimen of a light yellow colour, weighing nearly eight sovereigns, from the Breadalbane estate, near Glen Coich, in Perthshire. In some places, as at Vorospatak, near Abrudbanya, in Transylvania, the rock appears impregnated with small portions of gold, which occur crystallized and in slender plates disseminated through the mass. The mines of Hungary and Transylvania, Cremnitz, Schemnitz, Posing, Betza, Magurka, Nagyag, Offenbanya, and Boitza, are all worked for this metal, occasionally affording the most splendid specimens; and in Saltzburg, and thence along the chain of the Alps, as far as La Gardette, near Allemont, in Dauphiné, there are numerous other establishments of a similar description. The Russian and Siberian mines have also latterly afforded considerable quantities of gold; and to the United States it promises to be a mineral product of some importance."

Of its more general history M. Virlet (Coup Œd'il General et Statistique sur la Metallurgic) gives the following interesting summary:—

The discovery of gold, like that of iron, copper, lead, mercury,

tin, and silver, dates from the remotest antiquity. In the earlier ages the greater portion of gold was supplied by some provinces of India, and other countries in the south of Asia, to which the Phœnicians sent their caravans, in order to exchange for it their manufactures; and it appears certain that this maritime people traded for gold with the barbarous natives of the southern coast of Africa, as they did for precious stones with the natives of Ceylon. In Lydia, Mount Tmolus and the Pactolus, a river so celebrated by the poets, supplied a considerable quantity to Greece, where it was used in the statues of the gods, and in decorating the temples." M. Aug. Perdonnet and M. Virlet think it probable that, in these remote epochs, the practice, still in use, was adopted of placing the skins of sheep in the course of an auriferous stream, by which the scales and fragments of gold carried along by the current were intercepted and secured; and that the allegorical fable of the Golden Fleece originated in this custom. Egypt furnished large quantities of gold, the Egyptians, according to Herodotus, overturning mountains in their search for the metal. From the mines of the chain of mountains which separates Thrace from Macedonia, Philip king of Macedon, obtained annually more than 1,000 talents of gold, or about £225,000 sterling, by the aid of which he succeeded in corrupting the Greeks, and reducing them to subjugation, thereby preparing the way for the conquests of his son, Alexander the Great. (It is, at least, gratifying to think that the treasures in this metal now flowing into the social current will be used for great commercial rather than military triumphs, and be made conducive to the advancement of civilization.) About this epoch the Phœnicians having seized on the temple of Delphos, carried off the accumulated gold which had resulted from the offerings of the kings of Lydia at the shrine of Apollo, and the quantity, therefore, of the metal so increased in exchange, as to rise to a proportion of one to ten as compared to silver instead of one to thirteen, as had been its previous proportion. In Europe (Spain and Transylvania) gold was also obtained from a remote epoch.

The rarity of gold, combined with its ductility, its malleability, and the ease with which, in consequence, it can be worked, caused it be selected, with silver and copper, as the best represen-

tative of wealth—that is, of the capital or accumulated results of labour of all nations. Such a system naturally replaced the cumbrous exchanges in kind, which could only suit the rudest state of society; and though iron has also, with other substances, been used as a means of exchange, these three metals (to which may now be added, as an experiment, platinum) have become the money or representative of value of all civilised nations.

The auriferous sands of Brazil extend over a large space, and gold is abundantly found in them, mixed with platinum, the diamond, &c. In a similar manner, it is from such sands that most of the gold of Chili, Columbia, New Grenada, Mexico, Peru, the United States, and Hungary, Transylvania, Siberia, and the Oural chain, &c., is obtained; and also probably the gold of southern Asia found in the Indian Archipelago, that of Africa which occurs principally in Kordofan, and that obtained between Darfour and Abyssinia, in the neighbourhood of Bambouck, and at the foot of the mountains which give birth to the Nile, the Senegal, and the Gambia.

The mines of greatest importance in Europe are those of Hungary and Transylvania, the Russian mines being in Asia, in the chains of the Caucasus, the Altai, and the Oural. Thibet, which produced gold in the earliest ages of the world—as, according to Heeren, the Phœnicians traded for it there as well as in several regions of India—still continues to export to China and Bengal large quantities, as well as diamonds, pearls, copper, cinnibar, lead, iron, white lead, &c., for which they receive in exchange, mercury, porcelain, gold and silver stuffs, coined money, &c. Nepaul alone receives from Thibet about £210,000 worth of gold every year, the greatest portion of which is swallowed up in ornaments both of women and men. In British India gold has been found both in the beds of rivers and in the superficial alluvia in sufficient abundance to be worked; and the gold "diggings" of Calcutta have been long known, and are now subjected to proper inspection and regulation. The auriferous soil of India is, however, very poor as compared to the sands of Africa, yielding only about $\frac{1}{36}$ of the quantity of gold for the same weight of alluvial matter. The gold mines of Spain, though of great antiquity, have, like those of France, ceased to be of any

importance, though many European rivers, like the Pactolus of the ancients, produce auriferous sands, which lead occasionally to lucrative "diggings" or explorations. Amongst these rivers are the Rhine, the sands of which contain also a small quantity of platinum, the Rhone, the Hérault, the Garonne, and many others, including some of the rivers of Germany, Spain, continental Greece, Macedonia, and Thrace.

In the United States of America the exploration for gold has, independently of California, greatly advanced since 1824, when it supplied to the federal mint only about £1,095 worth of gold, whereas in 1837 it yielded about £195,850 worth. The states which yield the gold are North Carolina, which produces about half the quantity obtained, Maryland, Virginia, Georgia, Tennessee, and Alabama—states which form the south-west of the American Union; and it is supposed that the production is about double the quantity actually coined at the mint. According to M. Eschwége, the gold extracted in Chili doubled in quantity from 1752 to 1761, when it amounted in value to about £1,682,900 sterling—a rate of production, however, which it has long since ceased to maintain, having probably, in common with the other South American mines, diminished to at most one-half. It is, then, at a time when the returns of all the old existing gold mines, excepting those of Russia, have fallen to a very low ebb, that California has been unveiled to the speculatist, and beckoned to its rich bosom thousands of the adventurous youths of both Europe and America, there to seek the coveted gold.

To form a just idea of the effect which this new source of gold will have on the interests of society, it is necessary to inquire into the absolute products of the older sources of supply, and to ascertain their relation to the wants of society.

Mr. Henwood states that sixty-three millions' worth of gold had been extracted from the mines of Brazil, which were first known to the Portuguese in 1695. To the end of 1846, the Russian gold washings had yielded about twenty millions. Sir R. I. Murchison considered the returns from California to be about one and a-half million per annum; and the latest Russian accounts show a production of more than three millions annually, being, as well as the Californian mines, on the increase. The coinage at

the United States' mint in Philadelphia shows a deposit, in 1850, of

31,500,000	dollars' worth	from California,
1,650,000	„	from other places,
33,150,000		

So that California furnished to the Philadelphia mint, in 1850, £6,562,500 of gold—a quantity which probably exceeds that furnished from the rest of the world, and also that furnished by all South America in any one year.*

The money capital of Europe alone has been estimated at about £214,791,667. If, therefore, California continued to produce at the extraordinary rate of 1850, it would double the present capital of Europe in about thirty-five years; but there is little reason, from the experience of former gold-mining districts, to anticipate a similarly continued production. Let it also be remembered that population increases almost in the same ratio, and that the wants, therefore, of the commercial world almost keep pace with the Californian supply.

There is also an important deduction to be made, namely, the loss by wear in circulation, accidents, &c., which has been estimated at about three-fourths per cent., or on the money capital stated above £1,610,937 annually; and if the money capital of America were added, the loss could not be less than £1,800,000; but to this should be also added the quantity of the precious metals used in ornaments, &c., which has been estimated at about £6,250,000, and it will then appear that the annual consumption amounts to about £8,000,000.

As the supply of silver has diminished materially, we may therefore, as yet, consider this new source of supply in gold as fortunately coming in to relieve a growing scarcity of the precious metals, although it must ultimately, if continued, disturb the relation which now subsists between the money values of silver and gold.

I trust when the great importance of the subject is considered, as well as the vast social result which has already followed from the discovery of Californian gold, you will excuse me for thus placing it before you in detail. A new State has now been added to the American Union, and that region which, only a few months since, was one of disorder, is now ruled with equity and decision,

*Hampshire Telegraph. January 25, 1851.

and the returns of labour are insured by a proper distribution of the land to be searched.

The mode of distribution of some minerals may be illustrated by the occurrence in sea water of silver, copper, lead, and of silver in plants and organic structures. It may be reasonably supposed that just in proportion as a metal is more easily acted upon by those chemical solvents which are spread through nature, it will be conveyed from one division to another of the mineral kingdom. It is, indeed, with the mineral as with the organic fossil, that its distribution from the original place of its first appearance will be advanced by the facilities of dispersion afforded to it. Silver is an illustration of this principle, as it is one of the elements most diffused amongst metallic minerals. Messrs. Malaguti, Durocher and Sarzeaud, have been led, from a consideration of this diffusion, as well as from the ease with which silver combines with chlorine, even in contact with salt water, and its chloride dissolves in other chlorides, especially chloride of sodium, and the powerful action of sea water on its sulphuret, to seek for this metal in sea water; for, as these authors observe, if the sulphurets of lead, iron, zinc, and copper, with which sulphuret of silver is so often associated, are all acted upon by sea water, and their resulting chlorides are all soluble in that water, how can it be doubted that the metals themselves must be present in that menstruum which washes so many different strata, and which holds in solution more than one-third of the known elementary substances.*

Following up the search founded on these principles, the authors succeeded in discovering silver in the salt procured directly from the water itself, and copper and lead from fuci which had extracted them from the water, but failed in obtaining zinc: iron had, of course, long been known as a constituent of sea water.

The mean of thirteen experiments gave half a milligramme of silver for 50 litres of sea water, so that 100 litres would have yielded one milligramme; and if we speak approximatively, and call the litres kilogrammes (one litre of sea water weighing more than one kilogramme) the proportion of silver is $\frac{1}{100.000,000}$; that is, one myriametre cube of sea water contains 1000 kilogrammes of silver, a quantity below the truth, as much of it must

* Annales de Chimie. February, 1850.

have escaped calculation from the difficulties of determination. In English measures this would amount to 2,400lbs. in about 216 cubic miles—a quantity small, though amply sufficient to establish the fact, which the author had also done by the ordinary reaction of sulphureted hydrogen.

The research was now extended to marine plants, the power of which to condense and retain within their tissues the elements of the medium in which they vegetate, had been so fully established in respect to iodine and many other mineral substances.

From St. Malo the authors obtained a mass of sea weeds, from which they extracted

Fucus Canaliculatus,
„ Vesiculosus,
„ Serratus,
„ Ceramoides,
„ Nodosus,
Ulva Compressus.

These were dried and reduced to ashes with the utmost care, and by preliminary experiments it was ascertained that they contained of soluble and insoluble substances the following proportions :—

	Soluble.	Insoluble.
Fucus Canaliculatus,	75	25
„ Vesiculosus,	53	47
„ Serratus,	41	59
„ Ceramoides,	35	65
„ Nodosus,	62	38
Ulva Compressus,	41	59

The experiments were now made in the dry way, and the result of six analyses were as follows :—

1. Ashes of Fucus Serratus,	100	grammes,
Button of Silver,	0·001	„
2. Ashes of Fucus Ceramoides,	100	„
Button of Silver,	0·001	„
3. Ashes of Fucus Nodosus,	100	„
Button of Silver,	imponderable	

4, 5. The Silver was also inappreciable by weight, and in 6 doubtful.

From these experiments it is evident that all the fuci experimented upon contained silver; and, setting aside those in which the quantity obtained from 100 grammes of ashes was inappreciable by weight, it is evident that the quantity is really very considerable, amounting in fucus serratus and fucus ceramoides to $\frac{1}{100,000}$ part of the weight of the ashes. In other words, one pound of silver would have been produced from 100,000lbs. of ashes; and when we compare this comparatively great quantity with the minute quantity contained in the sea water, how strikingly and beautifully analogous is the assimilation of the metal in this case to that of carbon in ordinary plants.

The authors then proceeded to the examination of land-plants, and, making their experiments on those plants not subjected to the action of manures, which might have introduced silver into their tissues, conclude generally the presence of silver in plants—a fact which is perfectly in accordance with the general diffusion of silver throughout nature, and its association with most metallic minerals. The waters of springs percolating through mineral masses dissolve more or less of their chlorides, sulphates, nitrates, and other soluble salts, which, reacting in their course on metallic minerals, carry away in solution more or less of them; and, though the quantity may not be appreciable when sought for in so dilute a solution as the water of springs or rivers, it becomes recognizable when condensed and accumulated in vegetables.

It is thus that whilst the great forces of nature—combining, doubtless, electricity and magnetism—have been probably the agents for separating from the earthy mass metallic substances, and collecting them in the veins of massive and metamorphic rocks, the chemical powers of matter have been called into action to remove the metals from their places of deposit, and to spread them over the surface of the earth; and when these powers fail, the ordinary atmospheric agencies supply their place, and, as in gold and its associate metals, the distribution is effected by mechanical attrition and fluviatile transport.

There is one objection to these results which the authors anticipate and answer; namely, that the presence of silver in the sea may be consequent on the operations of man; but to this it may be replied, that if the whole of the sea contains the propor-

tion determined by their experiments, the total quantity of silver would be 2,000,000 tons, a quantity probably exceeding all which has been extracted by man from the earth: and even to carry the experiments beyond the age of man, the authors examined some rock-salt from the mines of Lorraine, and obtained from three kilogrammes, or seven pounds, a distinct button of silver. Whilst, however, this salt resembles the salt of our present ocean in this respect, it differs from it materially in containing only traces of sulphate of magnesia, without the muriate of that base, and in not as yet having produced either iodine or bromine, a fact which ought not to be overlooked in speculations on the origin of such masses of rock-salt. In experimenting on coal, the authors failed to discover such a quantity of silver as could be considered independent of accidental causes; nor is this surprising, as the vegetable matter forming the coal was doubtless deposited under circumstances which facilitated the removal of any mineral matter with which it might have been impregnated. They were, doubtless, estuary and not marine deposits.

The proportion of lead in the ashes of sea-weeds, of which fucus serratus, nodosus, and ceramoides formed the greater part, was determined to be $\frac{18}{1,000,000}$ grammes, and in like manner the presence of copper was also determined. This remarkable fact, that these three metals—silver, copper, and lead—are present in sea-water, is the natural result of their great diffusion in nature, and the ease with which they are acted upon by water either actually salt, or which contains more or less of the chlorides of sodium, &c., such as is the case with the springs which circulate in the upper portions of the crust of the earth. If, then, the presence of silver, copper, and lead, has been demonstrated both in the ancient and in the present oceans, such results are entirely conformable to the laws of nature.

We may add, that the presence of gold in plants was also long since stated by Becker and Hunkel, but has not been confirmed by subsequent experiments. Silver was discovered by Messrs. Malaguti, &c., in the blood of an ox. Lead and copper have also been found in animal tissues, but are supposed to occur only accidentally; and even as regards iron, which is present in almost

all organic structures, and manganese which is frequently present, Messrs. A. Chevalier and E. Cottereau are of opinion that the quantities are so variable that they cannot be considered essential elements of organic tissues, but merely as the result of peculiar food and circumstances.*

It does not appear to me that the great importance, as a geological fact, of the general diffusion of the alkalinic chlorides, bromides, and iodides, has been sufficiently appreciated. The recent discovery, by M. Chatin, of iodine in running fresh water streams, in fresh water plants, and in coal or the relics of ancient vegetation, adds additional weight to it. The diffusion of combinations of borine is an analogous and equally interesting fact. That element, like fluorine, is comparatively rare in nature, and yet is widely diffused. Rammelsberg† has given accurate analyses of the mineral tourmaline, which contains both fluorine and boracic acid, from thirty different localities of the old and new world, in most of which the quantity of boracic acid varies from seven to nine per cent., whilst the mean result gives about two atoms of boracic acid to seven atoms of silicic acid. I will not follow the author through his interesting discussion of the variations in the acids and bases of the mineral, but merely state that he has been enabled to form five distinct groups, classed under the two following heads:—

A. Brown and black tourmalines, without lithia.
   1. Magnesia tourmaline.
   2. Magnesia and iron tourmaline.
   3. Iron tourmaline.

B. Blue, green, and red tourmalines, with lithia.
   4. Iron and manganese tourmalines, blue and green.
   5. Manganese tourmaline, red.

My object is to point especially to the presence of boracic acid (a substance which is known to be emitted from volcanoes, or volcanic vents, such as the vapour springs of Tuscany, described by Sir R. Murchison) in the mineral matter of so many parts of the

* Annales D'Hygienne Publique. July, 1849.

† Poggendorff. Annalen, 1850, Nos. 8, 9.

earth's crust so widely remote from each other, is a fact of high interest. The probable agency of the volatile chlorides; fluorides, and, we may say, borides, has been already discussed in explanation of the formation and association of minerals; and, in respect to the extraordinary diffusion of the compounds which are the results of their action on, and combination with, mineral matter, it seems impossible to deny that so general an effect must have had a commensurately extensive cause. Is it, then, impossible that such gaseous bodies may be imprisoned below the consolidated crust of the earth in a state of liquid condensation?

After having thus shown that minerals and metals are most important geological elements, I may for a moment dwell with gratification on the Catalogue of the Simple Minerals of Trinity College, so ably completed by your late President, my learned and respected friend, Dr. Apjohn.*. This catalogue exhibits a praiseworthy desire on the part of the University to increase the mineral branch of its museum. In 1807 a descriptive catalogue, drawn up by the Rev. Walter Stephens, was edited by Dr. Whitley Stokes, an eminent member of the University, to whom the charge of the museum had then been committed, and the number of minerals described was 1,089. In 1818, Dr. Stokes, in conjunction with Dr. Thomas Taylor, a distinguished botanist, published a second catalogue, when the number of minerals described was 1,204. In the present catalogue the number described is 1,994, so that it has been necessarily a work of great labour. It would be out of place to examine minutely this catalogue on the present occasion, but when I consider the peculiar qualifications of its author, his extensive learning and his practical skill, I cannot but hope that he will make it the text-book for further inquiries into the deeper mysteries of the mineral kingdom. The form and properties of minerals are, in themselves, deserving of attention and study; but when we consider them as elements of the mineral mass of the earth, it is necessary that we should not merely divide the genera, such as the silicates, but also the species, such as felspar, hornblende, mica, tourmaline, &c., into distinctive groups, in order to

* Descriptive Catalogue of the Simple Minerals in the Systematic Collection of Trinity College, Dublin. 1850.

connect them with the rocks in which they are found, and to trace out the mode of their formation. Such is the course now pursued by eminent continental mineralogists, and there is no one here who could so well undertake the task as Dr. Apjohn. With him, then, we may hope and believe "that the growing taste for chemical and mineralogical studies within the University will be stimulated and extended by the ready access which the students have to its mineral collection, and that it will contribute to the cultivation of the natural sciences, an object in which the heads of the University have, for several years, manifested an especial interest;" an object, too, let me add, which fully deserves the enlightened support it receives from the University of Dublin, and from other similar institutions, as the study of the natural sciences cannot be pursued philosophically without obtaining glimpses of the formative causes which have operated under the control of a supreme intelligence in the production of such great effects.

From the contemplation of causes which act, as it were, unseen, we naturally turn to those which are more palpably manifested in their effects, and of these, water, as a physical agent, is one. In a short paper, which I read on the 10th April, 1850, I described some remarkable inequalities of the sea-bottom of the present Portsmouth harbour during the tertiary epoch, which I illustrated by the differences obtained in three Artesian borings at very short distances from each other. In the first, at the victualling yard near Gosport, the superficial clays and sands, and two great beds—the one 87 and the other 100 feet thick—of the London clay were passed through, when an abundant supply of water was obtained at 312 feet. In the second, at Block-house fort, one and a-quarter miles from the former, the upper eighty feet consisted of gravel similar to the shingle of the present beach, with occasional sand and silt, and a small bed of oysters, which was followed by the London clay, divided into three beds by sand, in the one case yielding bad water, in the other no water, as if it were entirely circumscribed by clay; at 310 feet good water was obtained in a bed of clean sand twenty-four feet thick. In the third well, undertaken in one of the bastions at Portsea, distant two and a-half miles from the Clarence Yard well, and with it, on a line parallel to the chalk escarpment of Portsdown, there was only a very slight superficial

covering when the London clay appeared, and continuing for the depth of 500 feet, was, with the exception of a few inches of intervening hard sand without water, followed by the plastic clay, which continued as one uniform mass for more than one hundred feet more, or to the depth of 610 feet, when the borings entered the chalk, and water was obtained, which rose to within three feet of the surface. Making every allowance for disturbance of the underlying rocks by elevation, I must consider these extraordinary inequalities as principally due to the unequal wear, at successive epochs, of the ancient sea-bottom, and the irregular distribution of mud or silt upon it.

Mr. James M'Adam, in his papers of the 8th May and 12th June, has given many curious details which link together the pleistocene strata with the post-tertiary detritus gravel or drift. It is thus that on the County Down side of the Lagan, near Knock, a bed of clay occurs, which overlies the variegated marl, and is covered by a bed of gravel and sand. In this clay, at an elevation of 150 feet, occur specimens of nucula oblonga, establishing, with its other contents, an identity with the clay found on the Antrim side of the bay, at an elevation of one hundred feet, and with the clay described by me in my Report on the County of Derry, as occurring inland, at various elevations exceeding those here stated, along an ancient chalk escarpment. But the sand and silt, on which the greater part of the town of Belfast is built, contains also the nucula oblonga; and as there can be little doubt that this ancient mud-bank extends continuously with the more recent deposits into the Lough, there is a remarkable blending together of two deposits, distinct as to age. Mr. M'Adam describes the gravel beds or ridges which border the Lagan, and continue as the boundary of the Lough on the Down side, being replaced on the opposite side by a clay bank; and he considers "that the entire valley of the Lagan, along with the Belfast Lough, has been filled with gravel and clay, and covered with water, comparatively shallow, which, gradually descending in level, has left its marks behind in the appearances described." Mr. M'Adam ascribes the depression of the water, which must have once covered these gravel ridges and mud banks, merely to the wear of channels by the water, and its gradual sinking or letting out, and does not think any catas-

trophe or elevating agency necessary to account for it. He quotes, in support of this opinion, the theory of M. Streffleur, who imagines that currents produced by the rotation of the earth wear into the sea-bottom, and gradually depress it, so as to drop, as it were, down the water—a general and shallow sea being thus changed into partial, narrow, and deep seas. Without, however, in any way questioning the changes which are doubtless effected on the sea-bottoms through the agency of currents, some of which tend to depress it, and some, by the addition of drift, to elevate it—and further, without doubting that many peculiarities and changes in gravel and clay deposits may be purely hydraulic phenomena—I cannot admit that there is sufficient evidence to deduce a fall of the mean level of the ocean independent of disturbances of the earth's crust; and I will but point to the great chain of the Andes, a vast ridge of comparatively recent volcanic matter, or matter of eruption, and which is transverse to the direction of currents of rotation, to show that elevations must co-operate with depressions in producing great general results of change of level. M. Constant Prevost has, indeed, objected to the term elevation, as apparently implying an unbalanced protrusion of matter; but, of course, this is not the actual meaning of the term, as there is, doubtless, a corresponding quantity of matter depressed. Mr. M'Adam enriches his interesting paper by a detailed catalogue of shells found in the silt and sand, and also partially in some of the gravel. His list contains seventy-one species.

In my communication on Bantry Bay I brought under your notice one of those examples of the scratching of rocks, by the passage over them of sharp detritic matter, the surface having been previously worn smooth and partially polished by a similar action. The example, which I described from my own personal observation, was taken from one of those bluff clay banks so common in Bantry Bay the interior portion of which—meaning that part within Whiddy Island—appears to have been formed by denudation of a comparatively recent date, or subsequent to the formation of post-tertiary deposits. The wear of this great mass of gravelly clay studded with boulders, or, in other words, of boulder-clay, is still continuing, and must continue, so long as any portion of it remains within reach of tidal action. As the

level of the water rises, the waves beat upon the base of the clay cliff, and gradually undermine it, until at length the top falls in, and for a time the base is protected by the fragments. When, however, they have been washed away the work of destruction is renewed, and slice after slice of the cliff or bank is thus removed, until, at length, the base retires beyond the action of the higher tides, and the cliff, exposed only to ordinary atmospheric agencies, finally crumbles into a slope fitted for the preservation of statical equilibrium. In the progress of this wear it is usual to find the boulders and larger gravel of the clay heaped up as water-worn shingle at the base of the cliff, the finer matter or clay having been washed away. It was at the base of a bluff headland of this boulder-clay, which is only exposed to the action of the waves in very high tides or in storms, and is, in part, protected by a bank of water-worn shingle, which had once been imbedded in it, that I observed a portion of the rock laid bare, which, far from exhibiting the jagged edges of the strata habitually exposed to the wear and tear of the waves, was smooth and rounded in its surface, and further marked by fine sharp scratches, varying in their parallelism according to the relative positions of the slopes of the rock and the consequent direction of the scratches. It further appeared to me that these scratches passed under the clay; and I therefore assumed, as probable, that they had been made by substances moving with or imbedded in the clay. It will be understood that I endeavoured merely to state a fact, and not to describe historically the phenomena with which that fact would be naturally connected. It is right, however, that I should now observe, that in my Geological Report on Tyrone and Londonderry, published in 1843, I have distinctly pointed out that the phenomena of drift are such as cannot be explained by any one movement of water, whether diluvial or fluviatile or marine, but are the results of actions often varied in their direction and amount, in a manner very similar to that which can be traced in more ancient deposits. In the illustrations to that work I have given examples both of contorted strata and of cross or false stratification in drift, and have contrasted them with similar appearances in secondary sandstone rocks. It is not the time to enter into an explanation of such phenomena further than to urge that they prove a long-

continued and regular mode of deposit, implying a sequence of strata. Nor do I see anything in their character which can, *a priori*, decide in any case whether they preceded or followed the deposition of boulder-clay. Local evidence has, however, proved that in some cases the boulder-clay preceded the stratified sands and gravel; but it is not impossible that, in other cases, marine currents may have swept over the surface of rocks, and hurried with them sand and shingle prior to the deposition of boulder-clay. If such were the fact the surface of a rock may have been smoothed and polished by the friction of the sand passing over it, and subsequently grooved and scratched by the more slow movement of glaciers or of boulder-clay.

I have now come to the point where I may fitly notice the paper or letter of a respected fellow-member, your former president, Mr. Robert Mallet, brought forward on the 11th December, in which he lays claim to priority in an explanation of the mode in which rocks have been grooved and scratched. Mr. Mallet states that, in company with Professor Oldham, he examined, in May, 1844, the cuttings of the Drogheda Railway made through the calpe, in the neighbourhood of Killester, and observed numerous scratches in the rock, and on the lower surfaces of boulders imbedded in the clay and gravel beds above it; that some of the scratches appeared to indicate that the superincumbent clay had been forced *en masse* up hill over inclined calpe beds; and that he concluded, from the evidence in general (and communicated his views on the subject to Professor Phillips and the Council of the Society, on the 5th June, 1844), that the scratches had been caused by the movement *en masse* of "the clay and gravel beds over the rock beneath, and that the scratches upon the latter, as well as those upon the large boulders reposing on the rock and imbedded in the clay, had been produced by their being carried over the rock along with the moving masses of clay and gravel." On the 12th Nov. 1845, Mr. Mallet read a paper on the subject to the Society, and then "ennunciated the doctrine that the lateral movement of masses of mud, sand, and gravel, while in a wet and plastic state, either under the sea or upon land very recently elevated above it, had been the great agent not only in the almost universal scratchings observable upon the surface of the rocks of every part of the earth, but had been also the means of transport of the far larger proportion of the boulders and greater drift masses that cover the earth." Mr. Mallet showed the close similarity that, in his opinion, exists between the motions, internal and external, of a moving mass of mud or sand and gravel, or of vast landslips, and of those of glaciers; and, at the Cambridge meeting of the British Association, again brought forward his views, adopting the term "mud glaciers," as illustrative of this supposed similarity.

It is thus on these grounds that Mr. Mallet claims priority of discovery, and complains that many geologists have adopted his mode of explanation without acknowledging or referring to that priority; and it becomes necessary, therefore, that I should set before you so much of the history of this branch of geological science as will be necessary to understand and to decide on this claim.

It is scarcely necessary that I should here observe, that by early geologists, with some exceptions, the existence of gravel and sand was ascribed to diluvial causes, and that scratches or marks of friction were considered evidence of diluvial currents. In Catcott, for example, the transport of detritic matter by the diluvial stream is strongly urged, and the wear of the strata by diluvial waters. In like manner these effects were ascribed to the movements of water, when Hutton and his pupils Playfair and Sir John Hall, had advanced and illustrated the theories of elevation of mountain masses and marine currents. Mr. Greenough (1819), in his critical essays, observes—"These theories refuted, there remains, in explanation of the phenomena of boulder-stones, the theory which attributes their occurrence, like that of ordinary gravel, to the action of running water. The arguments in favour of that doctrine are, that boulder-stones are evidently not *in situ*; that they are, for the most part, traceable to the parent rock, which, however distant, is always at a higher level than themselves; that they often rest upon beds either secondary or alluvial; and, lastly, that the upper surface of rocks protected by soil is, in many cases, so furrowed as to resemble a wet road along which a number of heavy and irregular bodies have been dragged, these furrows generally agreeing, in parallelism, both with one another, and with the ridges and large features of the district."

Mr. Greenough, not considering the force of running water, either as exhibited in the torrents of rivers or in the sea, sufficiently great to account for such results, ascribes them to the deluge. Hutton had ascribed them to the tumultuous rush of water consequent on great debacles, the result of sudden elevations of mountain chains or masses.

Dr. M'Culloch, in his System of Geology (1831), observes in his chapter on Changes in the Disposition of the Sea and Land,

"But I must not omit one argument supposed to afford a strong evidence of such diluvial currents; namely, the scratches or marks of friction already noticed in rocks where water does not now flow. Many of the quoted instances occur in places where rivers have once run, under the changes already pointed out; while if the others confirm the former existence of currents that could not well have been rivers, they are not competent to prove such movements of water as I have here rejected (diluvial). I shall inquire further of them presently, as the probable *effects of heavy* alluvia transported by water under other causes," an idea which is similar, if not identical, with that of Mr. Mallet.

Again, in his descriptions of alluvia, Dr. M'Culloch has one section denominated "alluvia of descent." He says—"The necessity of revising the alluvia has caused me to give this name to those which are produced by a combination of gravity, aided by rain, with the ordinary disintegration of the summits of mountains. These occur in all declivities, and consist of clay and sand, with fragments often of great size, which, if generally angular, are sometimes slightly rounded, from partial attrition or decomposition. Their real origin is indicated by their position, by tracing the progress of the operation, and by the nature of the substances. Their depths vary according to circumstances, and they often descend so far as to occupy the valleys beneath." "As these appearances occur in very gentle declivities, as in Cumbray and Isla, or almost on level ground, as near Comrie, here is a demonstrated cause of even transportation which geology has overlooked. That even boulders may have been gradually moved in this manner to great distances from the parent rock, is abundantly obvious; and I may here say, once for all, that whatever volumes may have been bestowed on these travelled blocks, there is no reason for separating them from the several classes of alluvia to which they belong"—an idea again identical with that of Mr. Mallet. M. Dausse, in his Essay on the Chaine des Rousses (1834), describes the mountain gorge of Flumay, which is formed by the junction of the granitic and gneisose rocks of the great chain of the Rousses with the slate escarpment of Côte-Belle. This deep ravine narrows at its bottom almost to a line, and has there a steep descending slope. On the left and towards the head of the gorge,

the gneisóse beds, which are above, have been greatly dislocated, and have produced huge accumulations of debris at the bottom. On the right, "the very bowels, as it were, of the mountain de Côte-Belle are exhibited as the various beds crop out in the steep escarpment. Strangely, indeed, is this escarpment ravined and grooved, and notched by the projecting of its several beds, and shaped into rugged asperities and bold needles, which are incessantly giving way and falling to the bottom. It is here that we find torrents or 'coulées de débris,' which the rains and great thaws have the power of moving. In this passage, M. Dausse almost seems to have Mr. Mallet's illustrative image of a glacier in his mind, but he contents himself with merely stating that huge accumulations of debris are made to flow down the course of a steep ravine by the increased power of water consequent on heavy rains or sudden thaws.

Quotations of a similar character might be multiplied, as the first mode of explaining the polishing and grooving of rocks was naturally to ascribe them to the passage of drift—or, as it was then considered, or at least called, diluvial matter—over them.

D'Halloy (1831), in his Elements, states, that M. Brongniart had observed portions of the primordial rocks (granites, &c.) where the surface had been polished and grooved in the direction of the trainées of debris, as if it had been worn by the passage over it of the blocks composing them. These trainées in Scania and Smalande form longitudinal hills, which the Swedes call 'as,' or 'ose;' our Irish escars. M. D'Halloy classifies, from the observations of M. de Beaumont, the drift or diluvium thus:—"It apparently occurs in three different forms. In the bottoms of valleys it appears as terraces, separated by a longitudinal depression, in which, like a secondary valley, is the ordinary watercourse; in plains it is spread out in vast horizontal 'nappes,' or sheets; and in mountains and hills it occurs as erratic blocks. It cannot be said that it exhibits a true stratification, though its masses often exhibit a partial parallelism. M. De Beaumont considers it generally in unconformable stratification with the strata which it covers; and, it may be added, that excepting where secondary valleys have been worn in it, the tendency of drift has been to

fill up hollows and inequalities, and to reduce the surface of the earth to horizontality."

It will be observed that the proximate cause of the polishing and grooving rocks was naturally sought in the passage of drift over them, and that to explain the cause of the movement of that drift was the real difficulty. Fluviatile, marine, and diluvial currents have all, in turn, been called into action; and had our learned member, Mr. Mallet, given us a clear and satisfactory explanation of a new mode in which such large masses of drift might have been put into motion and spread over the surface of the earth, he would, indeed, have deserved our thanks. His reference to the movement of landslips does not appear to me such an explanation, as it involves a generalization similar in character, and certainly more defective than that of Agassiz, in respect to glaciers.

It was, indeed, principally to supply the defective cause of the motion of drift that Agassiz endeavoured to generalize the phenomena of glaciers, so as to make them consistent not only with the drift of mountain valleys, but also with the immense detritic coating of the level plains below them. The effect of his first exposition of the phenomena to British geologists, who were not, like those of the Continent, familiar with the writings of Hugi, Charpentier, and Venetz, was truly surprising; and many of the most distinguished, headed by Dr. Buckland, entered upon the search for glaciers with the utmost enthusiasm. Nor has the subject lost its interest even now, as almost every season produces new examples of former glacial action on the mountains, humble as they comparatively are, of the United Kingdom. Agassiz was not originally an advocate of the glacier theory, but, as he informs us, considered the explanation of drift and its effects by marine currents more simple and rational. Personal intercourse, however, with Charpentier soon brought him to concur in the opinions of that author, and he became their most zealous and successful expounder. In one respect, the advocate for glacial action has this great advantage, that he can appeal to nature for proofs of the transporting power of ice—whether on land, as exhibited in the glacier, or in water, as manifested in the iceberg, or in the icefloe; and the real question, therefore, is, whether that transport-

ing power is equivalent to the effects which have been produced. On this point we may freely admit, as had been done long before, that the transport of large erratics is best explained by referring them to icebergs or icefloes. In like manner, the grooving and polishing of rocks within mountain chains, and even the arrangement of mountain drift, may be fairly ascribed to glaciers; but a doubt may be reasonably expressed whether either or both of these actions can explain the arrangement of the more widely spread drift of plains; and we are forced to call into our aid marine currents, more especially tidal currents, of which we shall again speak in the sequel of these remarks. It is right, however, to inquire first into the peculiar relations of the glacier to the effects we are now studying. M. Agassiz states (Etudes sur les Glaciers, 1840, p. 184), "The bottom of the glacier does not always rest immediately on the rock or ground, but is usually separated by a bed of sand or mud, which, according to its thickness, contributes more or less to the formation of terminal moraines. This bed proceeds from the fragments of rocks which fall under the glacier, either through its numerous cracks or by its margins, and are triturated into minute particles by the grinding action of the glacier as it moves along its channel. When glaciers move over granitic rocks, this bed is composed of very fine, white, and very loose sand; when, on the contrary, the moraines, which supply the materials, have proceeded from calcareous or slaty rocks, the bed is dark and pasty. It is to the small gravel contained in this intermediate bed that the characteristic striæ of polished rocks must be ascribed. In the upper valleys, this bed is frozen and adherent to the ground, whilst in the lower it is thawed. Independently of this bed of sand or mud, it is not unusual to meet under the glaciers a bed, more or less considerable, of small rounded blocks, varying from the size of an ordinary pebble to a diameter of six inches or a foot. These rounded boulders, which have been evidently triturated and worn like the sand by the movement of the glacier, strongly resemble the gravel beds of what have been called diluvial deposits, and, were they not so clearly connected with the glacier action, would be ascribed to powerful torrents. These beds of pebbles vary considerably in different glaciers, and are specially well exhibited under the gla-

cier of the Trient, where it is manifest that they proceed from the detritus of the sides of the valley, and are renewed continually as the more ancient portion of the bed is pushed forward to the lower part of the valley—a fact which negatives the supposition that the glacier may have been formed on a tertiary deposit."

M. Agassiz also points out that fragments encased in the ice act as files or rasps upon the rock when the glacier is in actual contact with it—a mode of operation which has been reasoned upon, whilst the other, or that in which a mass of detritus is moved with and under the glacier, has almost escaped notice.

Agassiz indeed says—" We have seen that the bed of mud and gravel, which is intermediate between the glacier and the bottom of the valley, contains a quantity of small fragments of very hard siliceous rocks, and, being moved on by the mass of the glacier, act as so many diamonds on the rock below, scratching its surface, whilst the mud and ice polish it. If," he adds, "the striæ and grooves under existing glaciers had been laid bare, and thereby made as distinct as those of extinct glaciers are, the connexion between the striæ and the action of glaciers would have been long since admitted, and an explanation of the phenomena neither sought for in currents of water or of mud."

I shall quote no further from M. Agassiz, and I have dwelt so long on the subject merely because I consider it of high importance to determine the real mode of deposit of the various descriptions of drift; and though I have observed a disinclination in many geologists to dwell on this or other branches of physical geology, I cannot but feel that it must ever be a reproach to geology if it cannot succeed in unravelling the difficulties which still obscure our explanations of drift, an operation which has taken place almost at the moment of man's birth. My predecessor in your chair had also occasion to refer to this subject in his address; and with his observations I partially agree, partially disagree. I cannot agree with him when he considers M. Martin's argument defective, in illustrating the possibility of glacier action in the mountain near Loch Lomond, at an elevation of 2,400 feet, by the discovery of such action in the Alps, 2,468 feet above the bottom of the valley which contained it. There is evidently no analogy between the case he adduces, namely, that as one rock (protogine, for

example) occurs in one district, the statement of its occurrence in another might be thereby established. Doubtless were some strange and apparently anomalous rocky compound said to have been found in some particular district, our belief of the possibility of its existence would be aided by a knowledge that it had been found in some other similar district; and in this way the glacier phenomena of the Alps may reasonably be called in to illustrate those of the Scotch and other mountains. I do, however, agree with my learned predecessor—and I had long since expressed that opinion—that it is dangerous, nay unphilosophical, to view the phenomena of all "so-called drift deposits only in connexion with, and as illustrated by, the phenomena of Alpine glaciers." On a former occasion I stated, as Sir R. Murchison has also done, that the composition of our ancient conglomerates and sandstones is, from the absence of boulders, such as not to lead to a belief that even glacial or ice action had existence at the time of their deposit; and if this opinion be correct, accumulations of ancient drift in sand, gravel, and mud must have then taken place through the agencies of fluviatile and marine currents alone. But let me ask, has the recent removal of any of the secondary or tertiary strata from the rocks below them, either by quarrying or fluviatile action, laid bare surfaces worn in the manner which has been described? I have seen evidences thus displayed of the ordinary action of water, but I have not seen the polished or striated surfaces. Often, for example, may be seen on the sloping side of the beds, the surface of micaceous schist, when recently bared by the removal of superficial strata, still exhibiting the well-known ripple marks, but no transverse striæ or grooves. I throw out this observation in the hope that the absolute antiquity of such markings may be defined. Whilst, however, I cannot limit the phenomena of drift to any one glacial cause, I must admit and acknowledge the vast importance of the recent study of glacier action, as without the demonstration of the more extended existence of ancient glaciers it would be impossible to satisfy the mind that a truly glacial epoch had occurred in the earth's history. The establishment of the former extension of glaciers naturally proves the greater amount of general cold, and prepares us to admit the floating icebergs and icefloes, which are assuredly the most natural and

efficient means of transporting the huge erratic boulders which have been spread over our now dry land. Such phenomena are now exhibited by the icebergs of our own seas, which convey fragments of rock thousands of miles from their natural seat; and would it not be truly unphilosophical to deny the possibility of such agencies at more remote epochs, or to refuse the corroborative evidence which ancient glacier action adduces in its support. But whilst the glacier and the iceberg were performing their parts, the river and the seas were not idle: and thus the true explanation of drift must combine the actions of all. One of these, namely, the simple action of the tidal current, seems scarcely to have been noticed in reference to this subject, though it has, doubtless, co-operated materially in producing some of the results observed. Almost every bay on our coast may afford evidences of the accumulation of gravel and sand by tidal currents; and it is very curious to observe how the shingle, or marine gravel, is sometimes moved over a smooth surface of sand. Nor is this the only effect, as I was enabled to observe, to great advantage, the action of the moving gravel in producing grooves in more solid substances, as exhibited in the breakwater at Southsea Castle, near Portsmouth, which has been worn in the most remarkable manner in deep parallel grooves, so as to assume the appearance of the most complicated mouldings. I have no doubt that a similar grooving takes place in ordinary rocks when favorably situated as regards the tidal current; and I would, therefore, suggest to every observer of such phenomena the inquiry, whether the grooving, as regards its physical position, is most nearly in relation to the action of a land glacier or to that of tidal currents.

Nor must fluviatile action be overlooked, as its power is very great under fitting circumstances. For example, can it be doubted that such a river as the St. Lawrence must, both by its waters and by the masses of ice it bears along upon them, convey large quantities of detritic matter, and arrange that matter at the bottom of the lakes in a manner very similar to that observed in the drift of our plains and estuaries. Other evidences of fluviatile action in pot-holes, &c., as pointed out by that eminent American geologist, Professor Hitchcock, should not be overlooked. On solid rocks the action of rivers is small, but on

the softer secondary strata, and on drift, it is considerable. In these latter cases they are modifying agents, removing and readjusting ancient drift, so that it is to more ancient rivers, or more ancient causes generally, that we must ascribe the drift itself. In making our selection between these causes we must not forget that a mere present difference of level between the point observed and the bottom of the valley or the stream running in it, is not a sufficient reason for rejecting the evidence of glacier action, as subsequent elevation has, doubtless, raised up the whole. In the glacial period when, as it is presumed, this extension of glaciers occurred, it is highly probable that our mountains were less elevated, whilst the limit of eternal snows was brought nearly to the level of the ocean. If, then, I consider a glacier as a true motive power applied by nature to transport drift, I consider it only as one power among many. I look upon it also as auxiliary to other glacial agencies, as it is the carrier by which detritus is conveyed from the mountain top and valley, until it is confided to the iceberg or icefloe, to be floated away to other and distant regions; but even with these restricted views of the geological agency of ice, it is evident that our knowledge of the phenomena connected with it cannot be too much extended; and I am happy, therefore, to see that it continues an object of zealous research. The cause of glacier movement has been much disputed. Many philosophers, Saussure, &c., ascribed it to gravity alone, or to gravity assisted by the flow of water below, which acted like a liquid roller to the mass; but, prior to this suggested explanation, Scheuzer had, in his "Itinera Alpina," propounded a different theory, namely, the expansion of a mass of ice by the freezing of water which had filtrated into its capillary cracks. This theory had been forgotten, when it was revived by Charpentier, and adopted by Agassiz. According to Agassiz, the process of formation goes on thus: first, snow which, by absorption of rain and other water and freezing, is formed into a granular mass called nevé, or firn. As the process continues, the nevé approaches nearer to the character of ice, until at length, beginning at the bottom, it is completely converted into ice. In the upper portion of a valley, therefore, the ice of a glacier must be necessarily covered deeply with nevé or with snow; but as the glacier moves

downward the greater quantity of water absorbed by this covering reduces it more and more to ice, and it seems, at length, to emerge as a simple glacier from the regions of nevé and snow.

This theory was controverted by Professor James Forbes, who adopted, as the result of his own observations, another, namely that of semifluidity. In his last or sixteenth letter on glaciers,* Professor Forbes again notices the progressive movement of a remarkable stone called "La pierre platte," lying on the surface of the glacier de Léchaud. This had moved, between 27th June, 1842, and 12th July, 1850, 2,520 feet, of which it had travelled prior to 21st July, 1846, 1,212, leaving 1,308 feet for the last four. The mean annu al and daily motion being as follows:—

	1842-3	1843-4	1844-6	1846-50
Daily motion, in inches,	9·47	8·56	10·65	10·81
Annual motion, in feet,	288·3	260·4	323·8	328·8

The movement of a large block near the centre of the Mer de Glace, from 1846 to 1850, was found to be 3,253 feet, the mean annual motion being 822·8 feet, and the daily 27·05. Professor Forbes now cites, in support of his theory of quasi-fluidity on glacier masses the experiments of M. Person, the French chemist, who states— "that ice does not pass abruptly from the solid to the fluid state; that it begins to soften at a temperature of 2° centigrade below its thawing point;" that, consequently, between 28° 4′ and 32° Fahrenheit, ice is actually passing through various degrees of plasticity within narrower limits, but in the same manner that wax, for example, softens before it melts. M. Person's words are— "Ice is, then, one of the bodies the fusion of which is most sudden, but, notwithstanding, that the passage from the solid to the liquid state is one by steps, and not abrupt." M. Person, as Professor Forbes states, obtains this result from the examination of the heat requisite to liquify ice at different temperatures, and not from its mechanical condition; and I, therefore, much doubt the validity of the conclusion deduced from it. In fact, it is very surprising that a direct reference should not have been made to the physical condition of ice—a reference so easy in our northern climates.

* Jamieson's Journal. January, 1851.

Is, for example, the ice formed on a frosty night in autumn and spring, and which still exists for some time after the temperature of the air has risen above 32°, in a plastic state? And, further, may not the peculiar relations to caloric, noticed by Person, be due to other causes connected with the physical condition of ice?

The researches of Hermann Schlagintweit,* on the Physical Geography of the Alps, and the extract given by him, in Poggendorf, of that part of his work which relates to glaciers, are most valuable documents in the examination of these questions.

Schlagintweit states that the ice of glaciers when exposed to the air falls into fragments or grains, which are loosely held together or locked by their projecting edges, the form of the grains being very remarkable, and strongly resembling the articulating portions of bones. Their size varies materially: in the upper portions of a glacier, or near the point where they emerge from the sea of nevé or firn, they are the smallest, seldom exceeding in volume $\frac{4}{10}$ inch cube. There are small hollow spaces between them, which are sometimes filled with air, sometimes with water. At points more distant from their origin the size of the grains, or elementary fragments, increases to two or three inches cube. It is to the grating or rubbing of the projecting portions of the articulating fragments that the peculiar noises of the moving glacier are due, resembling, in fact, the noises of a rusty hinge. The capillary cracks of the ice are ascribed to differences of temperature in the successive layers, or to the consequent differences of contraction, whereby the upper layers are split, as in the case of suddenly cooling metals or glass, into a network of capillary cracks. The greater the cold the more abundant the cracks, and the finer the network. It is to be remembered here that the expansion of ice is very great, being greater than that of zinc, tin, lead, silver, brass, iron, glass-rod, talc-spar, amounting to 0·0000375 for 1° cent., or, according to Struve, 0·000052.

The ice, therefore, of glaciers is composed of what may be called loosely articulated grains or fragments, mixed up with numerous air-bubbles or cavities, and divided by many capillary

* On the Physical Peculiarities of Ice, and their Connexion with the Phenomena of Glaciers. Poggendorf: July, 1850.

cracks. The frangibility of the ice is due to this condition, and it is to the ease with which, from this structure, the mass can move within itself that the power of moving over rough surfaces is derived; and it is due to this peculiar structure that ice assumes the character of a semi-fluid, or of a plastic mass. M. Schlagintweit also demonstrates the similarity of structure of ordinary water and glacier ice, excepting that the latter is peculiarly rich in air cavities, and is, consequently, more frangible. Ice, he concludes, exhibits, wherever we meet it, all the peculiarities of hard but brittle bodies.

In a short communication which I made to the British Association, at its Swansea meeting in 1848, and which has been published in "Annals of Philosophy," I pointed out that the ancient sands and gravels, which occur as sandstones and conglomerates in so many formations, exhibit no traces of the boulder phenomenon; and also, that no groovings or furrowings analogous to those which have been ascribed to glacial action have been discovered on the surface of rocks when merely laid bare by denudation. Every one is familiar with the ripple mark on slates, and all must have observed traces of ordinary wear by marine action, so that the absence of boulders and furrows must be ascribed to some great change giving rise to a new class of phenomena. I also pointed out, as Olbers had previously done, the absence of ærolites in the older rocks; and, though an example has been since discovered in the tertiary deposits, and it has been endeavoured to explain their absence from older strata on the supposition of rapid disintegration, I must still consider that such absence is due to some greater physical cause.

My friend, Mr. Henry Hennessey, allows me to quote the result of his paper read to the British Association at Edinburgh, in 1850, as bearing on this question. Mr. Hennessey first points out the comparative number of falling stars, fire-balls, and meteoric stones, which have been observed in the perihelion and aphelion portions of the earth's orbit, the former including the months from October to March, the latter the months from April to September; and cites the table given by Kaamtz, by which it appears that the number of the perihelion period was 334, and of the aphelion 254; and deduces therefrom that the number of meteorites which fall in-

creases as the earth approaches the sun. From various considerations Mr. Hennessey concludes that the sun's distance from the shooting stars, or meteorites, which fall so abundantly both in November and August, or in the perihelion and aphelion periods, is less than the mean distance of the earth from the sun; and hence that if the mean distance of the earth had been greater at some former epoch than it is now, the effect ought to be similar to that observed in the increase of its distance in passing from the perihelion to the aphelion,—namely, a diminution of ærolites. If, then, it be conceded that no ærolites did fall in the early geological epochs, it would appear probable that there has since been a similar diminution of the earth's distance from the sun. The general phenomena of the early formations, however, exhibit evidences of a higher temperature; and it is, therefore, reasonable to conclude that internal heat was the cause of elevated superficial temperature, which heat diminished to a minimum at the glacial epoch, when the gradual approach of the earth to the sun restored the balance and produced the present relations of temperature.

It now remains for me to notice the second great branch of our subject—natural or organic geology; and I regret that the contributions from our members during the present season have not been so extensive as to justify me in any very lengthened discussion of it. At the March meeting, Professor Oldham described the geological relations of the district extending from the Skerries northward beyond Balbriggan, the strata of which are much disturbed and altered by the intrusion of igneous rocks. He pointed out the fossiliferous nature of some of the rocks—a fact first made known by the Government geological survey; but I regret that he did not leave sufficient details to allow me to point out the nature of the fossil evidence thus obtained. In his last communication to the Society, in December last, he states that beds occur near Balbriggan which, from their fossils, appear to represent the upper limestone of the carboniferous system, and that the old slates east of the town of Wexford are shown, by the fossiliferous beds which accompany them, to be part, not of the Cambrian, or lower portion of the Silurian, but probably of the middle portion of the series. Here, also, I have no details on which I can offer further remarks. The labours of Mr. M'Adam, including his contribution of an

extensive list of pleistocene fossils from the mud and gravels of Belfast, I have already noticed; and I will only here request the attention of my friend, as regards his physical reasonings, to the paper by Mr. James D. Dana, on denudation in the Pacific.* That writer appears to consider that "running water of the land" was the great agent in the formation of valleys, or, in other words, of denudation. He, however, observes that—

"Although the sea can accomplish little along coasts toward excavating valleys, yet when the land is wholly submerged, or only the mountain summits peer out as islands, the great oceanic currents sweeping over the surface, and through channels between the islands, would wear away the rocks or earth beneath. From the breadth and character of such marine sweepings, we learn that the excavations formed would be very broad rounded valleys, and their courses would correspond, in some degree, with the probable directions which the currents of the ocean would have over the region in case of a submèrgence. Moreover, where there are different open channels for the ingress of the sea, having free intercommunication, there are often *strong currents connected with the tides, and consequently much erosion.*"

The tidal wave has, indeed, a manifest and great effect in the removal and arrangement of detritic matter, and ought not to be neglected in any consideration of the nature and formation of gravel deposits, or in a discussion of the organic remains they may have enveloped.

In April, 1850, I communicated to the Society some remarks by my relative, Mr. Richard Rubidge, a highly talented medical practitioner in the Cape country, on some facts connected with the geology of that portion of South Africa, and at a subsequent meeting I described some of the fossils he had sent to me. In the fossiliferous portion of the district, consisting of sandstone, marl, and shale, there are remains of many marine mollusca; and near the Sunday River, vegetable impressions. The latter will be hereafter more particularly referred to; and at present I shall only notice some few of the marine fossils which support Mr. Rubidge in placing the deposit containing them in the lias, or, at least, in a portion of the oolitic system.

1. Ammonites carusensis—D'Orbigny. The ribs appear to be interrupted, as in D'Orbigny's species, in passing over the front;

* American Journal of Science. January, 1850.

but it is closely allied to A. planicostata of Sowerby, and is evidently an oolitic form. D'Orbigny species was associated with gryphœa incurva in the lower lias of D'Angy-sur-Aubois.

2. A. Asterianus—D'Orbigny. The group to which this belongs is represented by several species in the oolitic system, though the present species is ascribed by D'Orbigny to the lower section of the neocomiens. The specimens are all very much larger than that described by D'Orbigny, and it is therefore very probable that it is nearly allied to, but not identical with his species.

3. Gryphæa incurva.

4. Pholadomya ovalis of Sowerby.—A fossil of the upper oolite.

5. Modiola plicatilis, Goldfuss.—An oolitic fossil.

6. Lyrodon Herzegii (Hausmann and Goldfuss).—A very beautiful species, which was also obtained by Hausmann, who considered the deposit green sand, at Sunday River. It belongs to the family of trigonidœ. The geologist will see in these fossils, which, with the exception of the Lyrodon, have all been figured from localities remote from the present one, an exemplification of the uniformity which has been supposed to characterise the faunæ of past epochs, and to be contrasted with the individuality of many local faunæ of the present epoch; but which is now less insisted on, as our most able Patœontologists consider the range of species equally great in our present system as it ever was.

Of labours not immediately connected with our own members, I shall only notice those which have a very general bearing on our science, the first of which will be the paper of M. Adolphe Brongniart, on "Periods of Vegetation, or Successive Floræ of the Earth," in the Annales des Sciences Naturalles, and subsequently in the Annals of Natural History.

The first object in studying fossil vegetables is, like that of studying animal fossils, to determine their relation to still existing organisms; but when this has been done it is necessary to examine the relations they bear to the strata in which they are found; and in doing this it is discovered that there are great differences in the nature of the vegetables which are successively developed, or which correspond to the successive epochs of the earth's history. In other words, that the plants which appear after each great revolution of the earth's surface differ materially from those which preceded it. Nor are the differences merely slight varia-

tions of a common type, but are usually very important changes, either new genera, or even new families, replacing those which have been entirely destroyed; or perhaps one family rich in genera and species, becoming reduced to very few species, whilst another, scarcely represented by a few individuals, suddenly becomes abundant and predominant.

These changes may be noted in the mere passage from one formation to another; but, enlarging the field of observation, this more general and important result may be stated—that, in the earliest ages, acrogenous cryptogamous vegetables prevailed, the ferns and lycopodiaceæ, or club masses; that next gymnospermous dicotyledonous plants, the cycadeæ and coniferæ, became predominant, without any mixture of angiospermous dicotyledons; and, subsequently, during the chalk, that angiospermous dicotyledons and monocotyledons appeared, and became predominant—a fact which M. Brongniart represents by dividing the long geological series of past ages into three periods: the reign of acrogenes, the reign of gymnosperms, and the reign of angiosperms—expressions which do not signify the positive exclusion of any one order, but merely the predominance of the others, excepting that angiospermous plants appear to have been nearly deficient in the two first reigns; for if their presence be admitted their forms were very different from those of existing angiosperms, and more approximating to monocotyledons than dicotyledons.

In the first reign, or that of acrogenes, M. Adolphe Brongniart includes the Silurian, carboniferous, and Permian systems—a result quite conformable with that obtained from animal fossils, as there is certainly a strong relation between the faunæ of these three epochs. In the second, or that of gymnosperms, he includes the trias and oolitic periods; and here, again, the analogy is supported by other organic fossils. In the third, or reign of angiosperms, he includes the cretaceous and tertiary—a result not so distinct as the preceding, though in the chalk a great approximation to the existing order of creation may be reasonably inferred to begin from the evidence both of vegetable and animal remains.

In the reign of the acrogenes, or carboniferous epoch, the most striking characters are the numerous species of ferns, the great development of the lycopodiaceæ and the arborescent form of the lepidodendra, to which may be added the occurrence

of anomalous families of gymnosperms, which are totally distinct from those now existing, having closed their existence with the reign of acrogenes, such as sigillariæ, næggerathiæ, and asterophillite. During the whole of this great period, from the Cambrian up to the Permian inclusive, there appears to have been no change in the greater characteristics of the flora, though certain genera and certain specific forms have prevailed more in one part of the series than in another. For example, the lepidodendra and calamites are more abundant in the more ancient, and the sigillariæ and coniferæ in the middle and upper beds of coal deposits. If the fossil flora be compared with the recent, two remarkable facts become apparent. The absolute number of species is small in comparison, since the carboniferous fossil flora of Europe contains only 500 species, whilst the number observed in the recent flora is 11,000, viz :—6,000 phanerogamous and 5,000 cryptogamic ; but if the ferns alone are compared the proportions are reversed, as the fossil flora yields 250 species, and the recent only 50. And, in like manner, the coniferæ and ephedreæ of the carboniferous epoch amounted to 120 species, whilst those of the present epoch are only 25.

This preponderance of cryptogamic acrogenes establishes an analogy between the vegetation of this early period and that of the small islands of the equatorial zone and southern temperate zone, in which a maritime climate is most fully established ; but with this exception, that in the existing epoch it is not connected with an exclusion of phanerogamous plants. In the Permian period the fragments, as it were, of this ancient flora remains, but no traces of it are discovered in the trias ; a conclusion which must be received with much caution.

The floral characteristics of the several tertiary deposits are thus stated by M. Adolphe Brongniart :—

1. In the eocene epoch, the presence of palms, as yet distinguished by extreme rarity, being limited to a small number of species. The predominance of algæ and marine monocotyledons, which may be attributed to the great extent of marine deposits during that epoch. The great number of conifers, and the presence of several extra European forms, principally resulting from the discovery of fossil fruits in the island of Sheppy.

2. For the miocene—The *abundance* of palms; the existence of a great number of extra European forms of plants, united with the genera of temperate and cold climates, and the presence of the genus Steinhauera, which appears to M. Brongniart a rubiaceous plant, allied to the morindæ.

3. For the pliocene epoch—The great preponderance and variety of dicotyledonous plants, the rarity of the monocotyledons, and especially the absence of palms; the general analogy being with the plants of the temperate regions of Europe, of North America, and Japan. Of curious deficiencies may be noticed the total absence, so far as our present knowledge, of compositæ, campanulaceæ, personatæ, labiatæ, solaniæ, boragineæ, &c.

The pliocene flora of Europe is distinguished from the recent, by the absence of mosses and ferns, and from the miocene and eocene, by the absence of palms.

In the modern tertiaries of the Antilles, however, palms are found, so that at that epoch they already there possessed the characteristics of an equatorial zone, whilst in Europe they were marked by those of the temperate zone.

Whilst, therefore, in the more recent tertiary epoch the general distribution of vegetables resembles that of the existing period, none of the plants of the one are actually identical with those of the other, unless the comparison be carried beyond the range of the actual fossil flora; for example, by comparing the fossil plants of Europe with the recent of America.

M. Jules Thurmann has published an extensive work on Phytostatics, in reference to the Jura and adjacent countries, principally with a view to determine the influence of the subjacent rocks on the dispersion of vascular plants; and of this work an abstract has been given in the Annales des Sciences Naturelles.* His object is to demonstrate, first, that there is an appreciable relation between the dispersion of species of plants and the subjacent rocks; and, secondly, that such relation depends on an influence connected with the physical properties, and not with the chemical composition of the rocks. Assisted by many French and Swiss botanists living in the Jura district, the author has compiled a complete table of the Jurassic flora, and added to it

* Annales des Sciences Naturelles. December, 1849.

one of species which are not truly Jurassic, but grow in that region; so that the whole affords a basis of comparison by which the facts of dispersion, as regards each species, in the various chains and valleys round the Jura, may be tested and established. M. Thurmann then discusses these facts of dispersion in reference to their causes, whether connected with climate or with soil. In the first place, he determines all the effects which may be reasonably ascribed to climate, in reference to annual temperature, differences between summer and winter temperature, rains, snows, springs, &c., and also the effects of latitude and altitude, and represents these elements of comparison on a topographical map of the Jura, by zones of colour and by thermometric curves, so that the proportion of the total effect due to these causes can at once be seen. In the next, he studies the subjacent rocks of the country, their distribution and principal *physical* and chemical properties, and adopts for them too distinct classifications—the one chemical, as calcareous, silicious, silicio-aluminous; the other physical, as eugeogenic and dysgeogenic. Amongst the rocks chemically considered, there are some which are easily disintegrated by atmospheric agencies, and give to the soil greater powers of division and of absorption of moisture—as, for example, sandstones, some granites, clays, &c.—and these may be subdivided into pélogènic or those which produce an earth soil or mould, and psammogenic which produce a sandy soil; and there are others which break up with difficulty, and yield to the soil only a close and stiff detritus, such as compact limestones, some porphyries, basalts, &c. The soils of the first class are more fresh and moist, and those of the second more dry and barren. The country was then mapped and coloured in groups characterised by these properties; thus, for example, the Jura and the porphyritic portion of the Vosges are dysgeogenic districts, whilst the tertiary valleys, the granitic Alps, the classic Vosges, are eugeogenic, partly psammogenic, and partly pélogènic. The Jura, in reference to its levels and latitudes, is first divided into four zones; and it is observed, that where the structure of the chain is the same, certain species of plants regularly appear at fitting exposures within them. The lower region extends to 400 metres, and is characterised by vineyards and maize crops, which encircle, like a girdle, the hills; the

second, from 400 to 700 metres, has neither vines nor pines, but is clothed with evergreens; the third, or mountain region, from 700 to 1,300 metres, is characterised by pines and the great gentian; and, lastly, the Alpine region, from 1,300 to 1,800 metres, is pasture grass. These regions are so neatly marked, that they may be recognised by the vegetation from about twenty-four test or characteristic plants. Having established these relations, and extended them from the Jura to the adjacent districts, M. Thurmann takes up the great question of the influence of the subjacent rocks on the distribution of the plants. This influence, he shows, may be traced in the most striking manner, even at the line of contact of two rocks suitably distinct from each other; and having studied the peculiar sympathy, as it were, or dislike of certain plants to certain rocks, he shows that the facts of dispersion prove that this elective tendency is exercised not so much in reference to the chemical as to the physical characters—the appearance or disappearance of plants depending not so much on the recurrence of calcareous or silicious soils, as on those possessed of eugeogenic or dysgeogenic properties; and he therefore classes the plants as hygrophiles which elect moist and fresh or eugeogenic soils, and xerophiles which elect the drier or dysgeogenic soils. The general comparison of the results of all these examinations, conducted on the graphic principle now so familiar both to mathematicians and statists, leads them to this important result. The state of the vegetation, or flora, of a country—that is, the dispersion and arrangement within it of plants—depends primarily on latitude and altitude, which are the principal elements or factors of the climate; and, secondarily, on the subjacent rocks: or, if the climate (made up as the effect of all its factors) be the same, the dispersion of floral species depends on the mechanical properties of the subjacent rocks, or on the strength, state of division, and absorbent power of the soils produced by their decomposition.

This work of M. Thurmann is of the highest value to the philosophical geologist. In applying its principles to practice it must be remembered that the detritus of rocks is rarely stationary, but is first transported from high to low lands, from the mountain top to the shores of the ocean, and there is spread, by tidal and other marine currents, over its bottom. Such transport

of detritus has been in progress since the earliest geological epoch, and must, therefore, from the beginning, have affected, more or less, the dispersion of plants. If, then, we compare these observations with the facts I have before noticed of the recurrence of the phenomena of elevations, and the intrusion of igneous matter in certain definite directions, we may reasonably imagine that as these points were elevated above the level of the sea, they became centres of vegetation; and that the grouping of species commenced in relation to the properties of the several rocks; and that the dispersion from these centres followed the direction and modification of the peculiar detritus or drift suitable to their organic peculiarities. In like manner it is easy to imagine how the conditions which had fitted a soil for the maintenance of one class of vegetation may, by physical changes, have been rendered unfit for its support, and hence the sudden disappearance of a flora in the passage from one geological formation to another.

It is not to be supposed that M. Thurmann intends to deny any chemical influence, or influence of composition, of the soil on vegetation. On the contrary, he distinguishes it where it exists, and first eliminates it, as mathematicians would do, before he draws his conclusions. In fact, the quantity of mineral matter which exists in the ashes of vegetables of all kinds, demonstrates their action on the soil, and, in like manner, a reaction of the soil upon them. The necessity of attending to this reciprocal connexion between the soil and the plants growing upon it, is every day becoming more evident, as agriculture is assuming a decidedly scientific character, and the farmer is forced to seek in the knowledge of the chemist and geologist a more sound basis for his practical operations than could be obtained from the mere trial and error of a rude agricultural system. M. Boussingault, who is remarkable in France for the combination of great farming and chemical knowledge, has paid great attention to this subject; but I shall merely quote the following results as illustrative of it. In one year, each of the following crops takes from the soil per acre:—

The Vine,	...	...	15·3 lbs. of Alkali.	
Potatoes,	...	...	58·8	"
Beet Root,	...	...	84·00	"
Barley,	...	...	25·20	"

The connexion, therefore, between inorganic and organic nature, and the reciprocal action of the one upon the other, are distinctly manifested in the vegetable kingdom; nor is the dependence of animals on the elements in which they live less remarkable. M. Agassiz,* whilst admitting fully the necessity of resting any natural classification of animals on their internal structure, as the only safe foundation, urges the propriety of again returning to some consideration of the natural relations which exist between animals and the elements in which they live: for though, as he observes—

"The mere living in water or upon dry land is in itself of slight importance, as there are so many animals which dwell in the two elements, although having the same *identical* structure, it should not be overlooked, that the greater number of aquatic animals have structural peculiarities common to all, and that the same is the case with the terrestrial or ærial animals; and that, not merely in reference to their respiratory apparatus, as the greater pressure under which aquatic animals are maintained throughout their life, modifies in many other respects their organization."

It is thus that whilst anatomical structure decides the zoologist in forming his classes of mammalia, birds, fishes, reptiles, insects, mollusca, &c., he is forced to observe that a modification of the normal structure was necessary to adapt it to a terrestrial or to an aquatic life. Having premised thus much, M. Agassiz endeavours to show that the aquatic type is always an inferior degree of organization. Taking, for example, the four great divisions of the animal kingdom, as adopted by him, namely, the radiata, including the three classes of polypi, jelly fishes, and echinoderms; the mollusca, including cephalopoda, pteropoda, gasteropoda, acephala and brachiopoda; the articulata, including anthropoda, crustacea combined with cirripedia, and insects; and, finally, the vertebrata—he finds the lowest grade of structure in the aquatic type, with some exceptions, such as the cephalopoda as a branch of the mollusca—an exception which deserves the special attention of the philosophic geologist. In like manner, the fluviatile types rank higher in structure than the marine.

* "The Natural Relations between Animals and the Elements in which they Live," by L. Agassiz.—*Silliman's American Journal*, May, 1850.

"These views," M. Agassiz observes, "are fully sustained by the order of succession of these great types of the animal kingdom throughout the earlier geological periods; for, as it is already ascertained from zoological comparisons, that the earlier types in each class rank lower than their present living representatives, we have further evidence, from the circumstances under which they live, that they were all aquatic and marine in the earliest periods, and that fluviatile and terrestrial types have followed only at later periods. Without alluding to those classes in which the gradation of fossil types is less distinctly shown, let me only recall the crinoids among echinoderms, which for so long time prevailed, to the almost entire exclusion of all other families among acephala; the great prevalence of brachiopoda in the oldest deposits, and the first appearance of naiades in tertiary beds; the large number of branchiate gasteropoda up to the time of the tertiary period, when limneæ and helices made their first appearance; the earlier development of crustacea with more uniform joints, and the appearance of insects of the tribe of scorpions anterior to that of the winged families, among which the neuroptera seem to be the first to increase in number; and the late occurrence of the sucking tribes in tertiary beds, and there will be no doubt left that the gradation of structure is intimately connected with the extension of continental lands, and that the present connexion of animals with the surrounding media in which they live agrees also with their natural gradation."

It is rather to this particular conclusion than to the general reasons of our author that the geologist should direct his attention. The apparent exception in the cephalapoda, as a branch of the mollusca, is, indeed, a strong confirmatory proof that the gradation of structure was not one of mere progressive improvement, but was the result of adaptation to the gradually altering circumstances of the earth's surface. The cephalopoda are highest amongst mollusca, and almost rival in the complication and development of their structure some of the vertebrata—and yet they are exclusively marine. It was, however, in the earlier stages of the earth's history that these animals exhibited their fullest development; and when we contemplate the numerous genera which have been discovered in the strata of the earth, from the orthoceridæ and nautilidæ of the earlier formations, to the baculidæ and ammonidæ of the chalk, and the singular variations from the more simple forms which they exhibit, it is impossible not to see that they indicated a modification of a normal form calculated to place the resulting organization in relation to some pecu-

liar circumstances of an aquatic or marine period, or, as M. Agassiz expresses it—

"The peculiar relations of this class to its type must be rather appreciated under the point of view of the conditions which prevailed in former ages, when the ocean covered more extensively the whole surface of the globe than at present; so that the type, with its high organization, must be considered more with reference to its development in former ages, than to what it is now, as at present the class is proportionably reduced; and it is well known, that in earlier periods, however high animals might have ranked by their structure, they were all marine, as we know fishes to have been the only representatives of the vertebrata in the earlier periods."

In truth, were it necessary to vindicate the claims of divine power, as manifested in creation, this modification of one organic type through a vast variety of forms, would afford one of the strongest arguments in its favour; and we may at least conclude from it that the necessary relations of the animals to the medium in which they were to live, led to the high and varied development of lower organic types rather than to the adoption of higher types, which were suited to circumstances not yet existing. M. Alcide D'Orbigny* has published two essays on this subject. The first treats on the successive progress of organization on the surface of the earth from the most ancient geological epochs to the existing one. The mode of discussing the question is different from that adopted by M. Agassiz, but is equally interesting. M. D'Orbigny first states, that in the animal kingdom the number of orders continued, with only slight exception, to increase in successive epochs, the numbers being as here shown:—

In the Palæozoic epoch, ...	31
In the Triasic "	21
In the Jurassic "	41
In the Cretaceous "	41
In the Tertiary "	71
In the existing "	76

In the aggregate, therefore, the quantity of animal forms increases, in respect to orders, on approaching the existing epoch.

* "Annales des Sciences Naturelles," April, 1850.

M. D'Orbigny next demonstrates, that though the total number of orders has thus increased, there is a very remarkable difference in the manner in which the several orders have been developed at successive epochs, some having obtained their maximum number of genera at some past geological epoch, and having now dwindled down to a comparatively small number, whilst others have continued to increase in number of genera up to the present epoch; or in other words, there are thirteen orders in a state of successive decrement, and sixty-four orders in a state of successive increment. If, then, more than one-sixth of the whole number of orders is in a state of decreasing development, and further, if this decrease has commenced in some at a very remote epoch, it is manifest that all the series of the animal kingdom have not advanced in one uniform progression of development. In the palæozoic period six orders had already attained their maximum of development, and begun to decrease, namely, placoid and ganoid fishes; trilobitic crustacea; tentaculiferous cephalopodes; brachidous brachiopoda, and fixed crinoids; or representatives of each great zoological division. In the Jurassic period, two orders began to diminish—namely, the saurian reptiles and the free crinoids. In the cretaceous period, four orders have passed their maximum of development and begun to wane—namely, the cirrhidous brachiopoda, the bryozoa, one section of foraminifera, and the sponges; and finally, in the tertiary period, two orders enter upon the wane—namely, the pachydermata and the edentata.

This result M. D'Orbigny considers in opposition to the theory of progressive perfection in development, and he then proceeds to examine the position of the thirteen decreasing orders in their respective branches of the animal kingdom, with a view to the same question. Beginning with the radiata, he finds that four orders are in a state of decrement, and twelve in that of increment; and of those in decrement whilst two orders belong to the lower forms of radiata, the echinoderms, which ranked as the highest, have furnished the others, one order having attained its maximum development many geological stages before the amorphozoa, which are at the very bottom of the animal scale. The radiata, therefore, do not conform to the supposed rule of progressive perfection of development. In the mollusca, four orders are in decrement,

and ten in increment, and those in decrement include the tentaculiferous cephalopodes, which attained their maximum of development in the silurian or earliest known zoological epoch, being two stages before the maximum development of the brachidous brachiopoda, twenty-one stages before that of the cirrhidous brachiopoda, which are inferior to the former, and twenty-two stages before that of the bryozoa, which are the lowest in organization of this branch of the animal kingdom. In the articulata the comparison must be imperfect from the perishable character of their structure, so that only one order appears in decrement, and eighteen in increment. The order in decrement is that of the trilobites, which belongs to the crustacea, and is more perfect in organization than the annelida and cirrhipeda, although the trilobites attained their maximum of development in the silurian epoch, and disappeared almost immediately afterwards, whilst the annelida and cirrhipeda have only attained their maximum in the existing epoch. In the vertebrata five orders are in decrement, and twenty-three in increment, being a ratio of nearly one to five, which is certainly very great in a branch so high in organization, and including man. In examining the orders in decrement, two belong to fishes, the placoids and ganoids, which far from being at the bottom of the scale in organization, are superior to the pleuronectidæ, still in a state of increment; and even include the squalidæ, which are superior to all other fishes in organization, so that in this class the highest development of the most perfect form took place at the earliest, and not at the latest epochs. In reptiles, the saurians which attained their maximum development long since, and now are in decrement, are superior both to the ophidia or serpents, and the batrachea or frogs, which are both in a state of increment; and, finally, in the mammifera, the pachydermata or elephants, and the edentata, are superior in perfection to the cetacea, which are still in a state of increment. It seems, therefore, evident, that there has been no general advance of organic perfection in successive epochs, but that some orders of a high degree of organization have anticipated others of a much lower degree, and that in each great branch of the animal kingdom the orders which have first attained their maximum of development have not been the lowest, as to organic structure, of that particular branch. It appears to

me, that this reasoning is not only opposed to the theory of progressive development, but founded as it is on facts, supports the conclusion I have already drawn from the essay of M. Agassiz, that organic perfection was attained at every epoch, estimating that perfection by the adaptation of the organic structure to the circumstances in which the animal was required to live. The second essay* of M. D'Orbigny is equally important in reference to this subject. In the thirty-one orders which have been already discovered in the palæozoic strata, each great division of the animal kingdom is fully represented, namely—the radiata by eight orders, the mollusca by nine, the articulata by eleven, and the vertebrata by three, so that the organization of the earliest periods was by no means confined to the lowest forms of animal life; and when these divisions are individually examined, it is found that of the eight orders of radiata, four belong to the echinodermata or the highest, and only two to the amorphozoa, or the lowest of the division. Of the nine orders of mollusca, some represent each class, and the most perfect class, the cephalopoda, is at its maximum of development in combination with a similar high development of the most perfect section of brachiopoda; of the articulata, some are also found to represent each class, and the coleoptera, or the most perfect, are amongst the insects; and of vertebrata, fishes and reptiles appear to have commenced with a great development of their higher forms of organization. The mammalia alone attained their highest perfection and their most extended generic development in the existing epoch, and were totally absent from the palæozoic fauna; yet even in this case, true mammals commenced not with the lowest, but with a high form of organization, namely—with the pachydermata and edentata. In like manner, birds commenced in the triasic period, and exhibited in the waders an order quite as perfect as the palmipedes of the chalk, and other orders subsequently developed; and chelonian reptiles appeared also in the trias or long before much more imperfect orders subsequently developed; so that the supposed progressive advance of organization through successive ages of the world, from a low type to one more perfect, rests only on the mammifera, and may be considered

* Recherches Zoologiques sur l'instant d'apparition dans les ages du monde des ordres d'animaux comparé au degré de perfection de l'ensemble de leurs organes Annales des Sciences Naturelles.—Ap. 1850.

an exception, principally founded on the late appearance of man upon the earth. The several divisions, and even the classes of the animal kingdom, have had a parallel development at each epoch of the earth's history, and the peculiar preponderance of some of them, or the absence of others, must be ascribed not to the necessity of some law of progressive improvement, but to the required relations of their organisation to the elements or circumstances of their intended existence.

The remarkable development of the pachydermata just before the commencement of the existing epoch, and their sudden diminution and almost disappearance in regions where they had abounded, is a fact of the highest interest, and is thus stated by M. Paul Gervais.* Of hoofed animals, the ancient French fauna possessed eight species of proboscidea, belonging to the genera elephas, mastodon, and dinotherium, all of which are extinct; forty-nine or fifty species of herbivorous pachyderms, of which only the ass and horse now exist; of omnivorous pachyderms thirty-five species, of which the boar and hog only remain; and of ruminants fifty species, eleven of which still live, either as wild or domestic animals, in France, and three, though extinct in France, are still found alive in other parts of Europe. Is it unreasonable to attribute the sudden disappearance of 125 or 127 species of animals of the great order of hoofed animals, including so many of large size, and the preservation of genera so valuable for domestic purposes as the ox, the goat, the sheep, the camel, and the horse, to a wise preparation for the ultimate occupation of the earth by man? And can we doubt that those powers of destruction which were bestowed on many of the gigantic reptiles of earlier geological epochs, have been replaced by the exercise of a lesser amount of physical force, guided by a higher intellectual power, as exhibited in man, the last and most perfect work of organic creation?

I have endeavoured thus far to set before you some of the more general and philosophical results which are the consequents of careful inquiry into the organic peculiarities of the earth in successive ages; and it is my intention to defer, until I again address

* Comptes Rendus. October, 1850.

you, an analysis of these detailed Palæontological works which are still in progress, contenting myself at present with only a few general remarks. In setting before you the views of M. Alcide D'Orbigny, I have had occasion to use the terms brachidous and cirrhidous brachiopoda, and I must therefore make you aware of the classification which that author has proposed for this class so important to the geologist. After commenting on the works of preceding authors, he points out the remarkable fact, that whilst one set of writers has attended almost exclusively to the anatomy of living species, the other, and far more numerous set, has diligently studied the external characters alone of the shells of extinct species. It is thus, he observes, that the arms, on the presence of which the name brachiopoda was established by Dumcril, and adopted by Cuvier, Owen, &c., seem to be almost forgotten; and the mantle so intimately connected with the organs of respiration, on which M. Blainville founded his term palliobranchiata, "has been scarcely mentioned out of the works of Cuvier and Owen." M. D'Orbigny, on the contrary, considering the presence or absence of arms to have a material effect on the extension and zoological characters of the mantle, adopts them as the basis of his proposed classification. He has thus two great divisions—

1st, Brachiopoda brachidea.—With arms; the borders of the mantle being only slightly developed, and the shell always symmetrical.

2nd, Bracchiopoda cirrhidea.—Without arms; the borders of the mantle much developed and strongly ciliated; shell rarely symmetrical.

The first division is subdivided according as the arms are fleshy, being free in their whole length, very extensible, and provided with rather short ciliæ; or fleshy, being sometimes supported on a shelly framework and always fixed, not extensible, and provided with long ciliæ. The first subdivision is divided into two sections, in the first of which the arms are rolled up in the same plane, and not supported by the internal processes of the lesser valve; and in the second, the arms are rolled up laterally and supported by the internal processes of the small valve.

The first section contains two subsections, namely one in which the shell has no hinge, and is composed of families 1 and 2,

the lingulidæ and the calceolidæ; the other, in which the shell has a hinge, and is composed of families 3 and 4, the productidæ and the orthisidæ. The second section is composed of families 5 and 6, the rhynchonellidæ and the uncitidæ. The second subdivision of the brachiopoda brachidea is also divided into two sections, in the first of which the fixed arms are supported in a shelly framework, and the shell is terebratuliform, has a hinge, and in substance is shelly, perforated, or fibrous; whilst in the second, the arms are fleshy, spiral, and united together, not supported by a shelly framework—the shell being conical, without hinge, deltidium, or area, and in substance either horny or perforated. The first of these sections contains also two subsections, one in which the framework which supports the arms is spiral, and the texture is almost always fibrous, being composed of family 7, the spiriferidæ; and the other, in which the framework is bent at angles, and the texture is always perforated, being composed of families 8 and 9, the magasidæ and the terebratulidæ. The second section is here also simple, and is composed of families 10 and 11, the orbiculidæ and the cranidæ.

The brachiopoda cirrhidea are divided into two subdivisions, in the first of which the shell and animal are regularly formed of symmetrical parts, in pairs, and the shell is always perforated, and never channelled, this subdivision being composed of family 12, thecidæidæ; in the second, the shell and animal are irregular, not being formed of symmetrical parts, in pairs, and the shell is not punctuated, and often channelled, the subdivisions being composed of families 13 and 14, caprinidæ and radiolidæ.

The characters of the families are thus given:—

1. Lingulidæ.—A pediculated external muscle passing between the two valves; shell horny; the beaks of both valves are equally grooved for the passage of the muscle, as in Lingula of Bruguiere; or the beak of one valve only, as in Obolus of Eichwald.

2. Calceolidæ.—There is no pedicle or external muscle; the animal and shell are free, and the texture is fibrous, as in Calceola of Lamarck.

3. Productidæ.—No opening for a muscle; animal and shell free; shell often tubular or perforated. The family thus divides itself into genera: when provided with external tubes over the

whole surface, the hinge area being scarcely visible, Productus (Sowerby). When the tubes occur only along the hinge border, and the area is strongly marked, Chonetes (Fischer). When without external tubes, the shell not being perforated, and the two valves arched, but not bent, Leptœna (Dalman).

4. Orthisidæ.—An opening for the passage of a muscle; animal fixed; shell always fibrous, but not perforated. When the opening, which is round, is placed at the summit of the large valve, without trenching on the hinge area, Strophomena (Rafinesque). When the opening is placed below the summit of the large valve, and in the area; if raised, and in the centre of an entire semi-deltidium, Orthisina (D'Orbigny); if triangular, and occupying the whole breadth of the area, there being no deltidium, Orthis (Dalman).

5. Rhynchonellidæ.—An opening for the passage of an external muscle; animal fixed. When the opening is close to the hinge, there is no area, and the summit is entire, Hemythiris (D'Orbigny). When the opening is separated from the hinge, and placed under the beak of the great valve: if surrounded by a raised margin, the deltidium is double, and there is no area, Rhynchonella (Fischer); if the opening has no raised margin, the deltidium is simple, and there is an area, Strigocephalus (Defrance). When the opening, separated from the hinge, is placed at the extremity of the beak of the great valve, Porambonites (Pander).

6. Uncitidæ.—No opening for the passage of an external muscle; animal free; when the beak is detached, salient and hollowed below, Uncites (Defrance). When the beak is turned over on itself, if the processes of the arms are free in the middle of the small valve, and the interior of the valves has no plates or laminæ, Atrypa (Dalman); if the processes of the arms are fixed to the small valve by a vertical plate, and the interior of the valves is provided with plates, Pentamerus (Sowerby).

7. Spiriferidæ.—When there is no opening in the shell for the passage of a muscle; the animal is free, and the shell fibrous, Cyrthia (Dalman). When there is an opening for the passage of a muscle, and the animal is fixed: if the opening is triangular close to the hinge, there is no deltidium, and the shell is fibrous, whilst the opening trenches upon both valves, Spirifer (Sowerby);

or, if the shell is perforated, and the opening trenches on the great valve only, Spiriferina (D'Orbigny). If the opening be round, distant from the hinge, placed under the beak, in the middle of a deltidium and area, the spiral cave having its summit inferior, Spirigerina (D'Orbigny); or, when placed at the summit of the beak, without deltidium or area, the spiral cone having its summit on one side, Spirigera (D'Orbigny). The shell of both these genera is fibrous.

8. Magasidæ.—Opening close to the hinge and no deltidium: when elongated, the beak being entire, and the hinge without ears, Magas (Sowerby); when round, the beak being truncated obliquely by it, and the hinge is provided with lateral ears, Terebratulina (D'Orbigny).

9. Terebratulidæ.—Opening placed at the extremity of the beak, and separated from the hinge by a deltidium. When without area, the opening being round, and trenching more on the beak than on the deltidium, which is in two pieces, Terebratula (Brug.). When the area is considerable, if the deltidium is composed of two pieces, and the opening trenches more on the deltidium than the beak, Terebratella (D'Orbigny). If the deltidium has only one piece, and the opening is round and trenches on both beak and deltidium, Terebrirostra (D'Orbigny). Or, when the opening is a slit, and only trenches on the external portion of the beak, leaving the deltidium entire, Fissirostra (D'Orbigny.)

10. Orbiculidæ.—An external muscle, proceeding from an opening in the lower valve; the shell free. When the shell is testaceous and perforated: if the peduncle of the muscle of attachment proceeds from an opening in the beak of the lower valve, Siphonotreta (Verneuil et Keyserling); if the peduncle proceeds from a lateral opening at the summit of a conical valve, Orbicella (D'Orbigny). When the shell is horny, and not perforated, if the pedunculated muscle issues by a lateral opening in the lower concave valve, Orbiculoidea (D'Orbigny); if the muscle is not pedunculated, and issues from a lateral opening which occupies the external portion of a flat valve, Orbicula (Lamarck).

11. Cranidæ.—No external muscle, the shell fixed, in texture perforated, thick, and with a ramified limb, Crania (Retzius).

12. Thecideidæ.—When the shell is free, and has an attaching

muscle which passes through a large opening of the great valve, and there are internal salient processes, Megathiris (D'Orbigny). When the shell is fixed, and there is no external muscle of attachment, but there are two internal muscles, corresponding to channels, hollowed in the upper valve, Thecidea (Defrance).

13. Caprinidæ.—Internal canals, penetrating into the substance of the shell by openings of the limb. When the upper valve alone has internal canals: if the canals are ramified, and communicate with the exterior of the shell, the whole shell being conical, Hippurites; if the canals are simple, not ramified, are compressed, and with communication with the exterior, the general form of the shell being spiral, Caprina (D'Orbigny). When both valves are provided with internal canals, if the canals are unequal and round, the lower valve conical and the upper spiral, Caprinula (D'Orbigny); if the canals are equal and capillary, the lower valve spiral and the upper valve opercular, Caprinella (D'Orbigny).

14. Radiolidæ.—No internal canals in the shell; limb simple or ramified. If the two valves are conical, the summit of the upper being central, and the limbs ramified and very lamellar, Radiolites. If the two valves are twisted, the summit being lateral, and often spiral, and the limb is simple, and not lamellar, Caprotina (D'Orbigny).

These characters I have extracted from the papers of M. D'Orbigny, in "Annales des Sciences Naturelles," May, 1850, which were originally read to the French Academy in 1847, and form part also of the great work by the same author, "Paléontologie Française," still in course of publication. It appears to me that the essay of M. D'Orbigny is the most comprehensive effort yet made to reduce to order this class, so interesting to geologists, and to combine together a due consideration of external form, and an attention to important anatomical characters. The result may not, indeed, be without defects; and the similarity of some of the names which vary round a common radical, will certainly require great caution to avoid confusion; but, such as it is, it must be received as a most valuable contribution to palæontological science. Such, indeed, is the accelerating progress of this science, that M. D'Orbigny has already found it necessary to form one new genus,

which he has separated from Radiolites, under the name of Biradiolites, and to admit another by the name Requienia (Mathéron), as distinct from Caprotina. In the Biradiolites are always observed two longitudinal bands, which extend in both valves from the beak to the lip, and are analogous to the two furrows of the Hippurites—such bands are never seen in true Radiolites. Requienia is distinguished from Caprotina by the obliquity of its valves, the shell always resting on its sides, by the absence of large internal teeth in the hinge and of internal conical cavities, which are replaced by isolated laminæ, or plates, which extend from the border to the summits of the beaks. The internal differences which are here cited between Caprotina and Requienia are very great, and show the difficulty of constructing any system which shall embrace every possible variety of form and structure without violating some of the analogies of nature. As the "Paléontologie Française" is still in course of publication, I shall only deviate from my rule so far as to point out some of its more general results. In the cretaceous formation, M. D'Orbigny describes 161 species of brachiopoda, which he thus apportions to the several stages, as characterised and named by him, of that formation:—

Neocomien	Lower, or True Neocomien,	22	40
	Upper, or Urgonien,	18	
Aptien,			5
Albien,			11
Cénomanien			33
Turonien			42
Senonien			34

On comparing these numbers, it appears that the period of maximum, as to numerical development of species, is nearly the same in the brachiopoda, the inhabitants of deep seas, and in the lamellibranchiata, or coast mollusca, certainly a curious result. An examination also of the species in each stage is full of interest: of the twenty-two species found in the néocomien proper, twenty are peculiar to it, and therefore characteristic, whilst two species, rhynchonella lata and terebratula hippopus extend into the urgonien stage, having either lived within, or been drifted into it. Of the urgonien species fourteen are characteristic, two have appeared in the preceding stage, and two extend into the suc-

ceeding. In the Urgonien appears the first zone of a new series of animals, the rudistæ represented by eleven species of the genera caprinella, radiolites, requienia, and caprotina. In the Aptien stage there are only three characteristic species, two having appeared in the preceding. All the eleven Albien species are peculiar to it, and characteristic. The thirty-three species of the Cénomanien stage are also peculiar and characteristic; and here appears the second zone of rudistæ, which were entirely absent from the two preceding stages, being represented by seventeen species of the genera caprina, caprinella, radiolites, caprotina, requienia. The forty-two species of the Turonien are also peculiar to that stage; and the third zone of rudistæ is composed of no less than thirty-five species of the genera hippurites, caprina, caprinula, radiolites, biradiolites, and requienia. Of the thirty-four species of the Senonien stage all are characteristic; but the rudistæ, so numerous in the last stage, are now represented by only ten species of the genera hippurites and radiolites. The rudistæ were accumulated in banks, like our oysters, and must, therefore, have materially influenced geological formations. I shall hereafter discuss the merits of the geological divisions of M. D'Orbigny, in which the principle of nomenclature introduced by Sir R. Murchison, in his *Silurian* system, has been so freely adopted. But I may here remark, that the specific distinctness of the several stages of the chalk formation in the brachiopoda is very striking; and should it be supported by all other classes of animals, would justify him in the rigid conclusions he draws from this and some preceding classes, namely—

"1. The limits between the faunæ of successive formations are strictly defined, as none of the species of brachiopoda of the jurassic or oolitic formation pass into the chalk.

"2. There are distinct genera, as well as distinct species, peculiar to each great zoological epoch.

"3. These changes of forms in successive faunæ are the more marked as the epochs are more important. The generic differences are greater between the oolitic and chalk formations than between the several stages of the chalk.

"4. Though between the several cretaceous stages there are affinities, yet each possesses either its peculiar genera or distinctive groups of species.

"5. The species of brachiopoda are, with a slight exception (about one per cent.), peculiar to particular stages, of which they are, therefore, characteristic, under all forms of mineral deposit.

"6. No transition being observable between specific forms, these animals appear to have succeeded each other on the surface of the globe, not by passage, but by extinction of the races existing at one epoch, and the complete, or almost complete, renewal of species at each successive geological epoch."

I shall only cite one more illustration from this great work, and I shall take it from the cephalopoda. The nautiloid type of cephalopoda, in which the chambers are separated by simple septa, appears amongst the forms of the earliest known fauna of the earth; and it is remarkable, that at that early epoch this type attained its highest development, and underwent every possible variation as to external form—so that there were in the Silurian fauna, straight nautili, or orthoceræ; obliquely curved nautili, such as phragmoceras and cyrtoceras; open and regularly curved, such as lituites; and though some of these abnormal forms continued on to the Devonian, and even to the carboniferous strata, they were, on the whole, upon the decrement, and quickly ceased, whilst the normal or simple form of nautilus continued on to the existing epoch. The ammonoid type, in which the septa are foliaceous, did not, on the contrary, appear till a much later epoch, for though the simple form of septum was departed from in the goniatites of the carboniferous strata, the distinctly foliaceous septum first appeared in the muschelkalk or in the trias. In the oolitic formation, the normal form, in which the volutions are all symmetrical to one plane, and are either contiguous or enveloping, is preserved through a great number of species, which differ in other respects materially from each other; but, at the same time, a deviation from the normal form begins to occur, the curious genus Turrilites appearing in the Sinémurien, or lowest of the ten stages into which M. D'Orbigny divides the jurassic or oolitic formations, and the genera Ancyloceras, Toxoceras, and Helicoceras in the Bajocien, or fourth stage; and it must be also observed, that the presence of most of those genera in the oolitic formation has only been recently established. It is, however, in the cretaceous formation that the type of ammonidæ undergoes the greatest variation, and exhibits almost every possible divergence from the normal form in the

genera Crioceras, Toxoceras, Scaphites, Hamites, Ptychoceras, Baculites (or straight ammonites), Turrilites, Helicoceras, several of which will recall similar variations on the normal form of the nautilidæ in the Silurian epoch; and, in like manner, after this great exhibition of the power of creative intelligence in adapting the shapes of other shells to the habitations of cephalopodous mollusca, the type not merely dwindled back into a simple form, like the nautilidæ, but in this case totally disappeared. Independently of its zoological interest, the course of development of the ammonidæ, when compared with that of the nautilidæ, seems to me a strong reason for believing that we do not see in the nautilidæ of the Silurian epoch the earliest cephalopoda of that type, and that there were organic stages, or faunæ, the traces of which we shall yet discover, if they have not been obliterated by metamorphic action. M. D'Orbigny distributes the cephalopoda of the jurassic system amongst the following ten stages:—

1.	Sinémurien (sinémurium, or Semur) .	35	species.
2.	Triasic (adopting the English name) .	41	„
3.	Toarcien (Toarcium, or Thouars) .	60	„
4.	Bajocien (Bajoce or Bayeux) . .	53	„
5.	Bathonien (from Bath) . . .	20	„
6.	Callovien (Calloviensis or Kelloway) .	67	„
7.	Oxfordien (from Oxford) . .	69	„
8.	Corallien (calcaire corallien of Thurmann —Nerinæan limestone), . .	8	„
9.	Kimméridgien (from Kimmeridge) .	16	„
10.	Portlandien (from Portland) . .	8	„
		377	

And it is very remarkable that the ammonidæ, which formed a large portion of the great members of the sixth and seventh stages, were all belonging to the normal form, or genus ammonites. Of the above, all the species of the first, second, and third are characteristic, or as yet known only in their respective stages. Of the fifty-three species of the fourth, one is doubtful as to position, and specially belongs to the next stage. Of the twenty

species of the fifth, sixteen are characteristic, one is doubtful, and three occur in the sixth. Of sixty-seven species in the sixth, sixty-one are characteristic, three appeared in the preceding, and three extend into the following stage. Of the Oxfordian, or seventh stage, sixty-five species are characteristic, three have been cited in the preceding, and one occurs in the succeeding stage. In the Coralline, or eighth stage, there are only five characteristic species, two having occurred in the Oxfordian, and one extending into the Kimmeridge. Of the ninth, or Kimmeridge cephalopoda, fourteen species are characteristic, and two appeared in preceding strata. The eight species of the tenth, or Portland stage, are all characteristic.

In the fifth, or Bath, and the eighth, or Coralline stage, there is a remarkable disproportion between the number of species of cephalopoda and that of other classes, the total number of species in the Bath stage being 532, while that of the cephalapoda is only 20, and the numbers in the coralline being respectively 638 and 8. This curious disproportion M. D'Orbigny explains, by referring to the very few points of the ancient geological shore of France of these epochs, on a level with floating bodies which have been noticed, and adds, "they are, as it were, fragments of ancient coasts, on which have been deposited some remains of those floating bodies which then swarmed in the seas of those epochs." M. D'Orbigny, who believes in a more rigid limitation of zoological epochs than some other geologists, states, in conclusion, that in nine successive faunæ the cephalopoda were renewed by distinct forms or species; and in respect to the small number of species which occur in more than one stage, he considers that their presence does not prove that they existed at more than one epoch, as it may in most cases be accounted for on the principle of drift. It is, indeed, astonishing that bodies that are almost always buoyant, sometimes even when in a fossil state (a specimen of Ammonites cordatus having remained so after twelve stages of time), should not be found in greater numbers at various successive epochs. In estimating, indeed, the magnitude and zoological proportions of any fauna, it is necessary to exclude from it all those species which may have been derived from a pre-existing fauna by drift. In respect to the Devonian I have on a former

occasion enforced this rule; and there can be no doubt that in proportion to the number of manifestly drift beds, such as conglomerates and sandstones, in any formation, is the necessity of strictly adhering to it increased. It may, indeed, be assumed, that only those bodies can be deemed true members of the fauna contemporaneous with the drift which are either in such a condition as negatives the supposition of transport by drift, or are found under circumstances corresponding with their natural habitats, or though apparently drifted have never been observed in preceding formations, and may therefore have lived contemporaneously with, though distant from, the other members of the drift fauna.

Mr. Thomas Davidson* has carefully examined the species described by Valenciennes, in "Lamarcks Animaux sans Vertèbres" (1819), under the genus Terebratula, and gives figures of them all. These typical species are either in the museum of the Garden of Plants, or in that of Baron Benjamin Delessert, who is the present proprietor of the private museum of Lamarck, and were most liberally lent to Mr. Davidson. Such an examination as Mr. Davidson has thus effected is of the greatest value, both in settling the history of paleontological discovery and in clearing up that confusion which is so often the result of reference to species which are only imperfectly known by verbal description. He has also pointed out some few mistakes of M. D'Orbigny in the nomenclature of difficult species of terebratulidæ, and when the immense magnitude of the works which M. D'Orbigny has undertaken is contemplated, it may be considered praise that so few errors have been pointed out in the brachiopoda. As regards, however, the "Prodrome de Palèontologie Stratigraphique Universelle," and its accompanying work, "Cours Elementaire de Palèontologie et de Géologie Stratigraphique," in which M. D'Orbigny informs us, that "*all questions relating to geological generalities are fully treated, both as regards France and that portion of the world which is at present known to geologists,*" I cannot but fear that ample evidence will be found, in many defects, that such works are beyond the powers of any one individual. In the "Prodrome," for example, I cannot think that Crustacea, especially

* Annals and Magazine of Natural History. June, 1850.

the trilobites, exhibit a complete digest of all which had been done in investigating and describing that remarkable family, in which there is a development round a centre similar to that which I have pointed out in the nautilidæ and ammonidæ amongst the cephalopoda.

Mr. Thomas Davidson, in a second paper, describes and figures the internal calcareous supports of the ciliated arms of Terebratula pulchella (Nillson), and Ter. pectunculoides (Schlotheim), and also describes and figures Ter. Deslongchampsii (Davidson), a new species. He adds that it is his intention to publish shortly some views relating to the internal apophysary arrangements of Terebratula and allied genera, when doubtless he will enter into the general question of the subdivision of genera.

In the "Annales des Sciences Naturalles" of 1848, Messrs. H. Milne Edwards and Jules Haime commenced an elaborate history of "Polypiers," or of the hard, ossified, or stony parts of the bodies of polyps, and have continued it in the successive numbers of that most valuable journal. The same authors have since commenced a monograph of the British fossil corals, the first* part of which, containing the corals of the tertiary and cretaceous formations, has now been published. For the present I shall merely refer to the introduction, as it explains the general views of the authors on a class of animals so interesting both to the zoologist and geologist. Without dwelling on previous systems, I may observe, that Messrs. Milne Edwards and Jules Haime ascribe to the type of zoophytes the rank of a subkingdom, and divide it into two natural groups, one of which comprises all true radiate animals—echinodermæ, acalephæ, and polypi; the other, the spheroidal or amorphous zoophytes, spongidæ and certain infusoria.

In respect to this first step of classification, it certainly appears to me very desirable always to separate into a distinct branch those animals which are developed, as it were, round some typical centre, as we obtain thereby a much clearer view of the principles of organic creation, than by attempting to blend all animals into one general system. Of the radiate section, then, of zoophytes,

* Publications of Palæontological Society. 1850.

the class polypi forms the subject of our present consideration. Our authors agree with Mr. Dana in dividing the polypi into two sub-classes, Corollaria (the Actinoidea of Dana) and Hydraria (the Sertularian Polypi). The Corollaria are provided with a corallum or polypidom, by which terms are designated the hard or ossified parts of the body of a polyp, the corallum being in general calcareous and of various forms, such as tubular, cyathoid, discoidal, or basal. The corollaria are then divided into three groups or orders Zoantharia, Alcyonaria, and Podaetinaria. Of these the last, represented only by the genus Lucernaria, appears very aberrant from the normal type, as the polyp is not coralligenous, and though the gastric cavity is surrounded by four vertical membranaceous septa, the tentacula are pedunculated and discoidal, being organised much in the same way as in echinoderma, into which class it almost appears to pass as a simple or rudimentary form. The zoantharia are in general coralligenous, and include the polyps of almost all the known fossil polypidoms, so that the order is of the highest geological importance, the knowledge of ancient zoophytes being necessarily limited to that of their hard or stony polypidoms. One great peculiarity in this order is that each individual corallum which incloses more or less completely the inferior portion of the visceral or gastric cavity of the polyp has in general the form of a deep cup or a tubular sheath, the cavity of which is subdivided into a circle of loculi, by vertical septa affecting a radiate disposition; and the star-like appearance of calice thus produced is one of the most striking features of this zoological type. The hardened tissue of polypi is called by our authors, sclerenchyma; and the zoantharia are divided into two branches, according as this hardened tissue is present or absent, the sclerenchymatous, and the malacodermous or soft-skinned. The sclerenchymatous of former worlds can alone be studied by the Palæontologist, though it must not be concluded that none of the soft skinned were contemporaneous inhabitants of ancient seas. Of the sclerenchymatous Zoantharia, five sub-orders are distinguished as Zoantharia aporosa, Z. perforata, Z. tabulata, Z. rugosa, Z. cauliculata. The Z. aporosa are the most lamelliferous and stelliform of all the corollaria, are very numerous, and belong

to four principal and well-known families, the turbinolidæ, the oculinidæ, the astreidæ, and the fungidæ. In all these the corallum is essentially composed of lamellar dermic sclerenchyma; the walls are very seldom porous, and usually constitute an uninterrupted theca, so as not to admit of any communication between the visceral chamber and the exterior except by the calice; the septa are highly developed, completely lamellar, and primitively composed of six elements. There are no tabulæ or transverse horizontal septa, so that the visceral chamber remains open from top to bottom, or is only interrupted by irregular dissepiments which extend from one vertical septum to another, without joining together, so as to form a distinct discoid floor. In the turbinolidæ there are twenty-six genera, including Dasmia, which forms the aberrant group Pseudoturbinolidæ. Of these Cyathina and the various modifications of the cyathine type constitute the tribe Cyathinidæ, and Turbinolia and nine other genera Turbinolidæ. In the Oculinidæ there are Oculina and thirteen other genera, besides four genera of the aberrant group Pseudoculinidæ. In the Astreidæ there are seventy-nine genera besides Echinopora, which constitutes the aberrant group Pseudastreidæ, and Merulina, which forms a transitional group Pseudofungidæ. This great accumulation of genera is distributed into two tribes—the Eusmilinæ, in which the septa are completely developed and entire, their apical margin being neither lobate nor denticulate, the costæ are always unarmed, and the columella is often compact, or even styliform; and the Astreinæ, in which the septa have their upper edge lobulated, dentate, or spinous, and often imperfect near their inner edge, the costæ also spinulous, dentate, or crenulate, but never forming simple cristæ, and the columella in general spongy, rarely lamellar and never styliform, corallum in general massive. These tribes are further divided into many sections, but for the present it is only necessary to say, that amongst the Astreinæ we meet the well-known genera, either recent or fossil, Caryophyllia, Calamophyllia, Meandrina, Astrea. In the Fungidæ there are twenty-three genera, divided into three tribes, one of which includes the genus Fungia, and is called Funginæ. The next sub-order is that of Zoantharia perforata,

in which the sclerenchyma or coralline mass is, instead of being formed of imperforated lamellæ, always porous, or even reticulate. The walls which constitute the greater mass of the corallum do not consist of laminæ, are always perforated, and completely or nearly naked. The visceral chamber is almost completely open from top to bottom, and never filled up with dissepiments or with tabulæ. The madreporidæ form a family in this sub-order, including the genus madrepora. The number of genera in the sub-order is twenty-five.

The third sub-order, Zoantharia tabulata, is distinguished especially by the existence of lamellar diaphragms, which form complete horizontal divisions extending from side to side of the general cavity; the septa are more or less rudimentary, but are arranged in the same mode as in the preceding divisions. There are four families—Milleporidæ, containing eight genera, amongst which are millepora, and heliopora, and fistulipora a new genus founded by Mr. Frederick M'Coy; Favositidæ, comprising eleven genera, which include favosites or calamopora of Goldfuss, and halysites or catenipora of Lamarck; Seriatoporidæ, comprising three genera, of which seriatopora is one; and Thecidæ, consisting of one genus.

The fourth sub-order, Zoantharia rugosa, is distinguished by a different septal arrangement than that of the preceding, the primary number being four and not six, so that the calice assumes a crucial appearance. Or when true septal groups cannot be discovered, they are represented by numerous equally developed radiate striæ on the surface of the tabulæ which extend up the inner side of the walls; the corallites are always distinct, the septa are never porous, and the visceral chamber is in general filled up from the bottom by a series of transverse tabulæ, or by a vesicular structure, which often constitutes the principal part of the corallum. In the thirty-six genera of this sub-order occur amplexus coralloides (of Sowerby), cyathophyllum helianthoides (of Goldfuss), campophyllum or cyathophyllum flexuosum (of Goldfuss), strombodes, lithodendron, and lithostrotion. Three genera are added as uncertain Zoantharia, of which one is Mr. M'Coy's heterophyllia.

The peculiarities in the substance of the walls of the corallum were pointed out by Mr. Lonsdale, and they became important aids in classification, and the presence or absence of transverse tabulæ is also highly discriminating. I will not at present dwell

at length on the order Alcyonaria, though highly important both to the recent and fossil zoologist, and marked by great differences of form; Tubipora, Alcyonium, Gorgonia, Pennatula, are all well known, and types of families strongly separated from each other. In Gorgonidæ is the Corallium rubrum, or red coral of the Mediterranean, and in Pennatulidæ the genus Graptolithus, so characteristic of the Silurian system. Of the other two orders it is unnecessary to speak, as they have no bearing on geological science.

In applying the principles of this zoological classification to the geology of England, our authors begin with that very remarkable formation, the crag; and show that, separating Bryozoa, there are really very few true corals either in the red crag or coralline crag; and, in fact, that four species, mentioned by Mr. Searles Wood, in his Catalogue of 1844, are the only known polypidoms of the division. They belong to four distinct genera, each of which is represented by species in the other miocene formations, and none of which have been discovered in strata anterior to the elder tertiaries. Three of the genera are also represented by peculiar species in the actual fauna.

The corals of the London clay are more numerous, embracing a greater range of families and genera. None are considered specifically identical with those now living, or even with those found in the more recent tertiaries. Some species are common to the London clay and the "calcaire grossier' of the Paris basin; but most of the Paris eocene corals have not been found in the London clay, and many of those belonging to the latter have not been found elsewhere. These difficulties are explained as the results of peculiarity of habitat, the corals of the London basin generally resembling those of very deep water and of a loose muddy or sandy bottom; whilst those of the Paris basin are more like the inhabitants of rocky shores and shallow water. The total specific distinction between the corals of the London clay and those of existing seas, is a very remarkable fact, and proves, with many others, that the successive faunæ of the earth are not the results of partial modifications, but of complete renewal. It might be possible to conceive partial changes of the higher animals, and yet a continuation, as a sort of ground-work, of the great mass of the fauna; but when the change affects the lower as well as the higher, no partial modification can explain it.

There are very few species of coral in the upper chalk, and still less in the lower chalk; and it is remarkable that, in all probability, most of those found in England are peculiar to the British seas of that epoch. In the upper green sand corals are also few in species: in the Gault they are more numerous; but in the lower green sand they are again extremely rare, our authors having only met with one decided species, and that belonging to the great division of Zoantharia rugosa (so predominant in palæozoic formations), of which it is the most modern representative. This almost dying away of true corals in the most recent secondary and in the tertiary formations—the type of Zoantharia rugosa, so prevalent in older formations, only struggling on to the lower green sand—deserves especial attention, as another proof that successive faunæ indicate total and not partial changes in organic systems.

In noticing thus briefly this most important work of Messrs. Edwards and Haime, I have frequently cited the name of Mr. Frederick M'Coy; and I cannot but express my gratification that this young naturalist, who is one of ourselves, and commenced his labours in Irish palæontology, has, by steady perseverance and great ability in the examination and description of the fossils of the Woodwardian (which may now be termed the Sedgwickian) Museum, at Cambridge, laid the foundation of a great name amongst palæontologists. Mr. M'Coy now occupies the chair of Geology in the Queen's College at Belfast; and I would suggest to him and our active member, Mr. M'Adam, how much good might be done by their co-operation in working out the palæontology of the northern chalk and other formations.

The work of Messrs. Edwards and Haime is due to the Palæontographical Society, and adds to its claims on the gratitude of geologists; indeed, can it be possible to estimate too highly works proceeding from Professor Owen, Mr Searles Wood, the authors on whom we have been commenting, and others. The Monograph of Permian Fossils, by Mr. King, is one of these most important works, as it establishes fully the claim of the Permian strata, first separated as such by Sir R. J. Murcheson, to be admitted as records of a great geological epoch. The general evidence induces me, however, still to connect the Permian with the protozoic formations, and the trias with the

deuterozoic. M. Adolphe Brongniart has also shown that much caution is required in determining what strata should be really included under this denomination, the flora of the bituminous and cupreous schists of the Mansfeld Zechstein, and that of the Permian sandstones of Russia, exhibiting a widely different list of species, no species common to both having yet been discovered—a fact which naturally leads to the inquiry, whether so great a difference only marks distant local floræ, or is due to the effect of difference of epoch, such as is observed even in animals in the subdivisions of the oolitic and cretaceous formations.

Before I quit this branch of my subject, let me congratulate the Society on the efforts which the University of Dublin is making to extend and improve the Natural History Department of its Museum under the superintendence of our able Vice-President, Robert Ball. The beautiful series of antlers of the Great *Irish Elk* (as it is so commonly called), which exhibits the increase by age from the smallest to the most mature condition, is very remarkable, and, certainly, as yet unrivalled. The exertion too in palæontology of the Geological Survey, both in England and Ireland, correspond to the high scientific character of Professor Forbes, who directs that branch of a work conducted in chief by Sir Henry De la Beche. In Ireland the labours in the field have been productive of the most important palæontological results, as may be estimated by the fact kindly communicated to me by the present able local director, Mr. Jukes, that since 1835, when I first made known the existence of Silurian strata in Ireland, no less than sixty-nine new localities have been discovered by the Geological Survey. My localities were limited to Tyrone and Fermanagh, whilst these extend into Meath, Louth, Dublin, Kildare, Wexford, and Waterford; being most of them traced out in the field under the several directors, by my former zealous and most successful assistant, Mr. James Flanagan. The speedy publication of such treasure is much to be desired, and I could hope that Professor Forbes will call to his aid for such an object the talents of Mr. M'Coy. I feel that exhaustless as this subject is, I must now cease, and in doing so, I will only trust that I have not entirely failed in my effort to set before you the leading features of geological science. Never, indeed, has geology stood on so sound and exalted a basis as it now occupies, when every collateral science

is brought to bear on and illustrate it. The mathematician applies the resources of profound analysis to explain its phenomena, and the experimentalist aids by testing and repeating in the laboratory the processes which, on the grander scale, are exhibited by nature in the interior of the earth. There are, indeed, two distinct modes of advancing geological science, namely, by observing the facts of nature, separating, distinguishing, and classifying them, as has been done by M. Elie de Beaumont, in his Essays on Mountain Chains; or, secondly, by tracing experimentally the mode in which such great phenomena have been produced, as has been done so ably by Mr. Mallett. Then, again, Mr. Faraday has, by his beautiful discovery of a distinction between magnetism and diamagnetism, or as he calls it, between paramagnetism and diamagnetism, opened a way to the mysteries of cohesion and repulsion, and we seem to feel that by a change in these conditions of matter, and its effect on the cohesion or the fluidity of matter, the stability of the earth may at any time be disturbed, and its strata thrown into confusion. And, finally, the philosophical inquiries and reasonings of the palæontologist have unfolded to us the records of past organic worlds, and enabled us to trace fresh proofs of the wisdom of their Great Creator in each renewed exercise of his will and power.

Let us then, my friends, endeavour to show that we are deeply impressed with the real dignity and practical value of our science, and strive to keep in the advance rank of its most assiduous admirers and cultivators.

J. E. Portlock.

[After the delivery of my Address, Mr. Mallett, who was unable to attend at the Anniversary Meeting, intimated to me that he thought that I and others had misunderstood the enunciation of his theory. I have endeavoured to represent it as I conceived it to have been delivered originally by its author; but he now states that he intended to extend the principle of slips to detrital matter under water. At my next address I will notice the peculiarities of this enlarged view of the theory; but I must here observe, that no verbal statements to a society, unless they have been reduced to writing, and in some form or other made a permanent record, can be received in justification of a claim of priority. Were a different principle adopted, any vague perception, such as often floats in the mind of every ingenious man, would be put forward, and stand as a warning against the efforts of other inquirers, until its author had leisure to mature his ideas, and determine whether his theory could be established by an appeal to facts and nature.]

November 13, 1850.—"Notice of Scratches upon the Rocks of Bantry Bay, and of some intrusions of Igneous Rocks amongst the Schists, and consequent disturbance of the strata;" by LIEUT.-COL. PORTLOCK, R.E., President.

IN my passage to Whiddy Island, from Glengarriff, I was struck by the appearance of a bluff head-land of boulder clay on the main shore, and landed to examine it. It appears to be a portion of a great mass or bed, which, probably extended continuously over the inner portion of the bay, namely, the part which lies between Whiddy Island and Bantry, as many similar bluffs are observable at other points. On landing, I found that the schists exhibited ragged, projecting edges, where exposed to the free action of the sea; but walking over them towards the clay bluff, which was partially retired from the water's edge, I first found an edging of shingle, proceeding apparently from the wear of boulders which had fallen out of the clay, and then observed a portion of the rock at the very base of the cliff worn quite smooth and round, and, in a degree, polished. On this I noticed many very fine scratches, which had a partial parallelism, though occasionally affected in directions by the changes in the angles of the plane surfaces. It appeared to me that these scratches passed under the clay; and my impression is, that the whole mass must have moved onwards, and that the pebbles which produced the scratches were imbedded in the clay. The polishing of the rock itself may, however, have been the previous result of the passing over it of looser and finer materials, such as sand, as it seems difficult to attribute such an effect to any very slow movement of a boulder clay.

In further examining the schists, I found that they were penetrated by veins of igneous rocks, which seemed to have been protruded between the beds; and, on crossing to Whiddy Island, I found a most beautiful example of physical disturbance, probably due to such protrusion, in the counterscarp or side of the ditch of the East Fort. The contortions are of the most striking kind, as exhibited in the accompanying drawing, made for me by Mr. Murphy, the engineer contractor; and connected with them

is a curious instance of metamorphic change. The schists are here the carboniferous slates of Griffiths, but they are very much indurated and changed in physical characters, and exhibit a curious bed of lenticular nodules, or masses, some of which are three or four feet long, which follows the contortions of the other beds. Some of these have fallen out, and the cavities they have left are, on their sides, quite smooth, and almost polished. They are hard, and appear to the eye so like some trap rocks, that my first idea was to connect them with the rocks of intrusion. The analysis, however, undertaken, very kindly, by the Rev. Mr. Galbraith, dispels such a notion, and renders it evident that they were either calcareous nodules so common in shales, or parts of a calcareous bed, which had separated, under metamorphic action and contortion, into lenticular and independent masses.

The analysis is appended, and is remarkable from the great quantity of manganese. Whether this was original, or, together with the magnesia, was derived from the adjacent strata at the time of physical change, there can be little doubt that to its presence, and that of the silica, must be ascribed the peculiar mineral characters of the nodules, which in appearance assimilates them to igneous rocks.

December 11, 1850.—"Analysis of a Nodule found in the Slate Rock of Whiddy Island, Bantry Bay;" by the Rev. JOSEPH A. GALBRAITH, Fellow of Trinity College.

CaO, CO_2	=	80·30
MnO, CO_2	=	3·44
MgO, CO_2	=	1·04
Silica, &c.	=	8·21
Water and loss,	=	1·01
		100·00

"Besides these constituents there appeared traces of iron and alumina; but, as the quantities appeared inconsiderable, I did not estimate them separately. They were precipitated with the manganese, which, for that reason, will appear a little in excess.

Specific gravity = 2·709.

March 12, 1851.—"Notice of the occurrence of fragments of Granite in Limestone, County Dublin;" by the Rev. SAMUEL HAUGHTON, Fellow of Trinity College, Dublin.

THE quarry in which this phenomenon was first noticed is situated near Crumlin, Co. Dublin, a short distance from the road leading to Crumlin from Roundtown. The fragments of granite occur in only one bed of limestone, varying from six to twenty inches in thickness. The beds of the quarry have an inclination of 20° to 18°, which is very constant throughout the quarry. The dip is S. 23° W. (magnetic,) and does not alter sensibly in the portion of the beds which is exposed.

The bed in which the granite is found has been quarried through an extent of about sixty square feet. The fragments are pretty uniformly distributed through the whole of the bed which is exposed, and vary in size from about eight inches in diameter to the size of small grains of gravel.

The granite which is exposed in the neighbourhood of joints of the limestone is partially decomposed, and the felspar in some places replaced by crystals of carbonate of lime. It effervesces with acids, in consequence of the infiltration of carbonate of lime, from the surrounding limestone.

The fragments of granite are angular, and do not appear to have been rolled about by the action of the water. The nearest granite in situ is at least four miles distant, near Killikee, which lies nearly south of the quarry.

The most interesting fact connected with the occurrence of these granite fragments is the well-ascertained fact that they occur in only one thin bed; proving clearly that the causes which produced them did not operate continuously, but acted for a time and then ceased.

The other specimen of imbedded fragments of granite was procured by Mr. Greenwood Pim from Monkstown, close to the church, and appears to have been taken from the neighbouring gravel pit. It is a rolled boulder of limestone, and contains fragments of slate as well as of granite.

On examination it proved to be a *Dolomite*. It is highly crystalline and fossiliferous. Its analysis is as follows:—

MgO, CO_2	=	34·82	per cent.	·81 atoms.
CaO, CO_2	=	48·24	"	·96 "
FeO, CO_2	=	1·40	"	·02 "
Argil,	=	14·64	"	
		99·10		

This analysis may be approximately represented by the formula,

$$7\,(CaO, CO_2) + 6\,\left\{(MgO, FeO)\,CO_2\right\}$$

The following analysis of the Dolomite occurring between Williamstown and the Rock station of the Kingstown Railway, is added, to show that the boulder of limestone above described did not come from that locality:—

Argil,	=	15·06	per cent.	
FeO, CO_2	=	11·89	"	·205 atoms.
CaO, CO_2	=	47·21	"	·944 "
MgO, CO_2	=	25·64	"	·600 "
		100·40		

Giving an approximate formula for this Dolomite—

$$7\left\{CaO, CO_2\right\} + 6\left\{(MgO, FeO)\,CO_2\right\}$$

April 9, 1851.—"On the Geology of the South Staffordshire Coalfield;" by J. Beete Jukes, Esq. M.A., F.G.S.

Mr. Jukes commenced by giving a sketch of the geological structure of part of the midland counties of England. He briefly described the position of the carboniferous rocks of the great Penine chain, and the way in which they plunged beneath the great plain of the new red sandstone, their reappearance from under that formation, on the flanks of the mountains of North Wales, and in the coalfields of Bristol and South Wales. He then drew attention to the island-like coalfields of the midland counties—Leicestershire, Warwickshire, Staffordshire, and Shropshire; and showed that in this latter district the lower part of the great carboniferous formation, namely, the mountain limestone and millstone grit, and, also, the old red sandstone or Devonian

rocks, were almost entirely wanting, and the upper part of the "coal measures" rested directly on rocks of silurian or still earlier date.

He then proceeded to describe, in rather more detail, one of the most interesting of these isolated coalfields, that of South Staffordshire, of which Dudley might be considered as the centre.

This district is composed of rocks belonging to three geological formations.—1st. New red sandstone. 2nd. Carboniferous. 3rd. Silurian.

The silurian formation is here composed almost entirely of soft shale, locally called "bavin." It contains near the top a band of impure argillaceous nodular limestone, about twenty-five feet thick, referrible to the Aymestrey limestone of Sir R. Murchison, about 1,000 feet below which is the Wenlock and Dudley limestone, generally composed here of two bands about thirty or forty feet each. About 1,500 feet below this is another band of limestone, locally called the Barr limestone, which is likewise about twenty or thirty feet thick, and which, probably, is the same as the Woolhope limestone of Sir R. Murchison. Below this, again, but at an unknown depth, the top of the Caradoc sandstone appears in one part of the district.

The carboniferous formation consists entirely of true coal measures, having no representatives of the mountain limestone or millstone grit. Its maximum thickness is probably about 1,500 feet. Its upper portion is comparatively barren of good coal or ironstone, but in its centre and lower parts it is remarkably rich, it having in one part an assemblage of beds of coal, resting one upon the other, till they make a solid mass of coal, about thirty feet in thickness. This thick or ten-yard coal is generally made up of about twelve beds. It has, however, many changes and variations. In the south part of the district, about Stourbridge, some of its beds become worthless, and it is then considered as three coals. In the northern part it is divided by beds of shale and sandstone into many beds, which are not at all looked on generally as part of the thick coal. In the richest part of the district—about Bilston, namely,—the following is the normal section:—

Broach coal, and ironstone. Thick coal, Gubbin ironstone. Heathen coal, New mine ironstone. New mine coal. Fire clay coal, Poor Robin's ironstone. Bottom coal, Gubbin and Balls ironstone. Blue flats ironstone.	Total thickness about 500 feet or 170 yards.

As we go south, however, the coals and ironstones in the lower part of this section gradually deteriorate, and south of Dudley nothing is worked below the heathen coals. At the extreme northern end of the field again there are fifteen coals in a distance of about 600 feet, only one or two of which are four feet thick; there is little or no ironstone, and as the workings are quite isolated, it is at present impossible to bring them into corelation with the southern part of the field.

The new red sandstone is composed in this district principally of red sandstones, and conglomerates with an occasional band of marl, and in one part of the section there are one or more bands of impure calcareous sandstone, resembling the cornstone of the old red sandstone, or a calcareous conglomerate of pebbles derived from the mountain limestone. Many of the conglomerates are quite soft and incoherent, and under the name of gravel, have been confounded with the superficial drift of the country.

Besides these stratified rocks there are two kinds of igneous rock in the district. 1st. An old trap, an imperfectly formed syenite or porphyry, which is probably of silurian age, and which is seen only in the Clent Hills, in the extreme southern part of the district; the second is a basalt, of an age subsequent to the formation of the coal measures, which bursts through them at several places in the central portion of the coalfield in large masses, and burrows among them in great sheets over several square miles. This basalt in some places passes into a highly crystalline porphyritic greenstone, and in others (especially in its diverging dykes and veins), into a white feldspathic trap.

Such being the constitution of the rocks, their relations to each other are as follow :—

The new red sandstone on the southern border of the field seems to repose conformably on the upper part of the coal measures; there are, however, no beds of passage as there are beds of conglomerate at the base of the new red containing pebbles of coal, &c. Both formations are nearly horizontal, and, therefore, they of course appear conformable. Along both the east and west margins of the coalfield the new red is brought down against the coal measures by great down-throw faults, while along the extreme north edge of the field, the new red rests distinctly unconformably on the edges of the coals, which are worked beneath it, and crop gently up into it.

In like manner the coal measures appear at first sight to be conformable to the silurian, but are found really not to be so. When greatly broken by faults, or tilted up at great angles, both formations appear equally affected, but on the west side of the field the coal measures rest on the uppermost beds of the silurian, while on the east they repose on beds much lower, being the Aymestrey limestone in the one case, in the other the Dudley. Moreover in the cutting of railroads, cliffs of Silurian were seen with coal measures abutting against them and containing beds of pebbles; and near Walsall the lower part of the coal measures overlaps the limestone, so that it is evident the Silurian had a dip to west, and its edges were denuded before the coal measures were deposited on it, although the dip was so gentle as not to differ in any one spot more from the horizontal than the coal measures did when first deposited. Mr. Jukes then proceeded to describe the remarkable examples of unconformability of all these rocks at Lord Dartmouth's pits. He first of all, however, gave a short description of "rock faults," which are curious masses or cakes of sandstone that take the place more or less entirely of the thick coal in certain localities, and he showed that Lord Dartmouth's pits exhibited a complicated example of unconformability combined with a rock fault.

While on the subject of exceptional structure in thick coal, he described the "flying red," especially that near Kingswinford, and mentioned the important bearing of these two facts on the question of the origin of coal.

Mr. Jukes then entered on the description of the internal struc-

ture of the coal field, describing the principal anticlinal axis, which runs N.N.W. and S.S.E., but is not continuous. It stretches from Sedgley to Dudley, forming a ridge with three centres of local intensity, which produce three oval dome-shaped elevations—Hurst Hill, Castle Hill, Wren's Nest. South of Dudley, the force causing elevation was relieved by the bursting through and overflowing of the trap of Rowley Hills; but it appears again farther south, in the Lickey, where there is an anticlinal axis of Caradoc sandstone, with Wenlock shale and coal measures on each flank. This axis divides the field into two portions. The south-west portion has one longitudinal fault parallel to the axis, a down-throw to west of 40 to 100 yards; and several cross faults bending more or less, and running from this to the western boundary fault. Also, one small anticlinal axis, running N. by E. and S. by W.

The central portion of the field has rather a trough-like structure, between the ridge of Dudley and Sedgley, and the high silurian ground of Walsall. This trough is traversed by numbers of east and west faults, which gradually end in each direction, and have their greatest throw in the centre. Starting from Rowley Hill, and going north, the faults first of all throw down to the north 40 or 50 yards each, up to the Dudley port trough faults, which cause a throw of 130 yards in coal, but do not affect the silurian; from this as we go north the faults throw up to north so as to make thick coal crop at Bilston, &c.; then the other beds rise gradually to the north, up to the Great Bentley fault, which throws down again to north and brings in the bottom part of the thick coal. Another similar great down-throw to west beyond Daw end, brings in the Aldridge coals.

North of these localities the dip of the coal field is generally west at a slight angle, so that the upper measures at Wyrley, are really on a parallel with the thick coal. These stretch off to the north, but not being worked, are very little known till we get to Brereton-Wyrley, Brereton, and Brown Hill, being the only well-known localities.

Mr. Jukes then entered into an explanation of "trough faults," and of the method of their formation, showing how it is they affect the upper and not the lower beds, &c.

He then made some remarks on the practical question of finding coal below the new red sandstone, showing the prudence of not undertaking the search without sound geological advice; he described

the probable thickness of new red sandstone as 300 or 400 yards at least, while its unconformability to the rocks below rendered it possible, after piercing it, to come down on any other of those rocks, instead of the true coal measures.

Mr. Jukes concluded by noticing a new discovery of some beds of lias on Needwood forest, made by himself in 1850, and noticed the probability, from the existence of lias here and in Cheshire, that all the midland counties were once a great lias plain, and that the great boundary faults of the coal fields, while certainly more recent than the red marls, may even be newer than the formation of the lias.

June 11, 1851.—Account of a new Mineral species. Communicated by James Apjohn, M.D., Professor of Chemistry and Mineralogy, Trinity College, Dublin.

The mineral which is the subject of the present notice was brought to Dublin last autumn, by the Rev. Professor Jellett, who purchased it, with several others, from a mineral dealer, whom he encountered in the valley of St. Nicholas, in Switzerland.* Suspecting it to be an undescribed species, he placed it in the hands of Dr. Apjohn, Professor of Mineralogy in the University, who, after an examination of its physical and pyrognostic characters, saw reason to adopt the opinion of Professor Jellett, and committed it to Mr. H. Wright, one of the most experienced of his laboratory pupils, with a request that he would make a careful analysis of it.

This mineral occurs as a partial incrustation, of a dull greenish yellow colour, on the surface of a stone which seems to be an indurated talc schist, containing imbedded brown granular garnets, and a little adhering white asbestus. In the fracture it is quite compact; but must, nevertheless, be considered as composed of numerous aggregated prisms, the rhombic bases of which, having angles of about 60° and 120°, are distinctly seen on the exterior of the incrustation, particularly when it is examined with a lens. Its hardness is over 7, or it is situate, in the scale of Mohs, between quartz and topaz, the former of which it scratches with facility. Specific gravity = 3·741. Heated alone by the inner flame of the blowpipe, it slags, acquires a dark colour, and is then

* Since the reading of this notice, Professor Jellett, who has just returned from another excursion into Switzerland, has shown me some good specimens of this mineral, which he picked up himself last August (1851), on the Moraine of the glacier of Findelen, in the immediate vicinity of Monte Rosa.

strongly attracted by a magnet. When in a fine powder, it is acted upon by muriatic acid, but does not gelatinize. The acid takes up lime and iron, the latter exclusively, as Fe_2, Cl_3, leaving an impure silex, so that the decomposition is not complete.

19·45 grains, submitted to analysis, gave—

Silex, ...	7·39	37·99
Peroxide of iron, . .	6·53	33·57
Lime, ...	5·76	29·61
	19·61	101·17

And a repetition of the analysis, 17·09 grains being operated upon, gave—

Silex, ...	6·51	38·09
Peroxide of iron, . .	5·71	33·41
Lime, ...	4·89	28·61
	17·11	100·11

The results of both analyses agree perfectly, and conduct to the same empirical formula, viz.:—

$$4\,Si\,O_3 + 2\,Fe_2\,O_3 + 5\,Ca\,O.$$

But how are these constituents grouped, or, in other words, what is the most probable rational formula to which they correspond? This is a question of some difficulty; for if we assume, as is usually the case, that the peroxide of iron discharges the basic function, we are compelled to admit the presence of such a silicate as $5\,Ca\,O,\ 2\,Si\,O_3$, that is, of a compound which has not hitherto been found as a distinct mineral, or been recognised as a proximate constituent of any compound silicate. Under these circumstances, it would probably be allowable to view the peroxide of iron as acting the part of an acid or electro-negative principle, (its isomorph alumina we know frequently performs such a part), which will enable us to write the formula—

$$2(Ca\,O, 2\,Si\,O_3) + 3\,Ca\,O, 2\,Fe_2\,O_3,$$

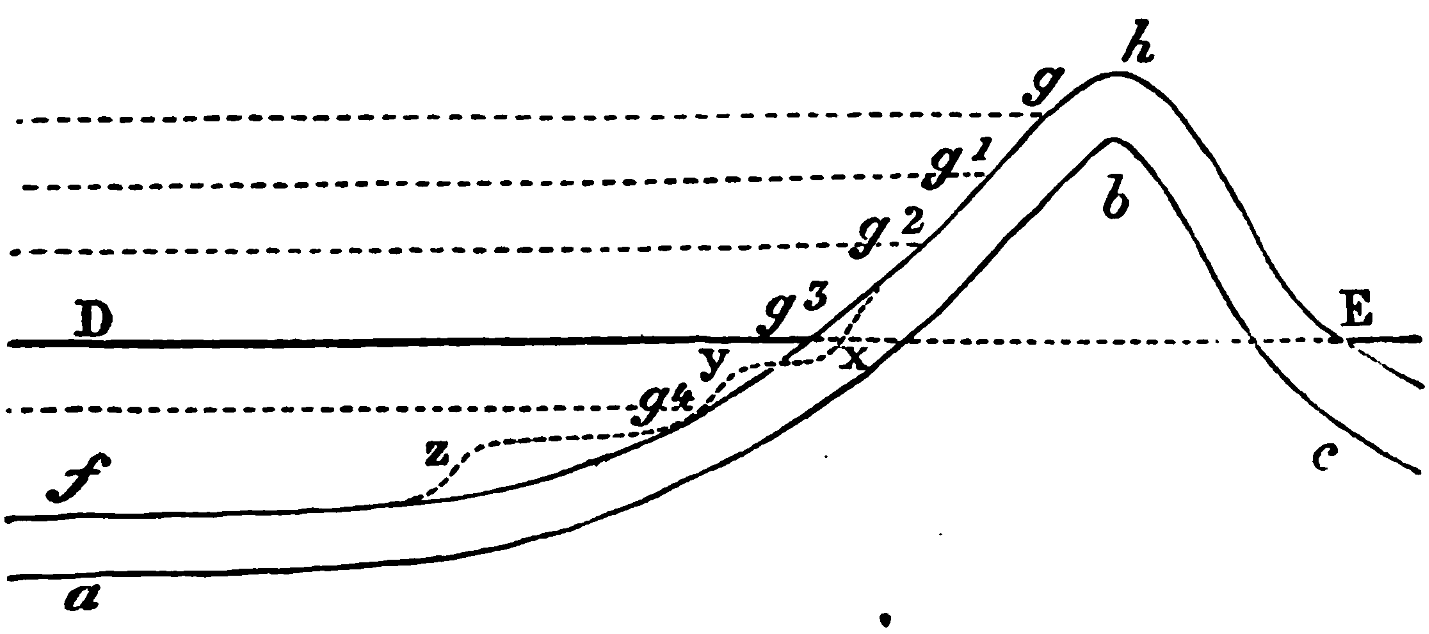
or to represent the mineral as composed of a bisilicate and subsesquiferrate of lime; compounds which have numerous analogies, and the possible existence of which may therefore be readily admitted.

This mineral, which is undoubtedly new, it is proposed to call Jellettite, after the distinguished mathematician through whose means it has been made the subject of chemical and mineralogical examination, and established as a distinct species.

June 11, 1851.—"Some remarks upon the Movements of Post-tertiary and other Discontinuous Masses;" by ROBERT MALLET, C. E., M.R.I.A.

SOME months ago, I believe about December last (1850), it may be in the recollection of the Society, that I addressed a letter to my friend, Professor Oldham, claiming priority of discovery with respect to certain views relative to the movements of detrital masses. That letter was, I believe, communicated to the Society at a meeting at which I was not present. In the last annual address in February, 1851, our President, Colonel Portlock, has impugned my claim to priority as respects the views affirmed by me in the above letter. I was unable to be present at the reading of that address, and as it is not yet printed, nor has any abstract of it appeared as usual in the newspapers or journals, I am unable to state from its words upon what authority Colonel Portlock relies for the contradiction which I understand him to have given to a claim to priority of discovery which I still deem well founded on my part.

But I have been furnished, in a private communication from Colonel Portlock, with the two authorities upon which he relies, and which I understand him to have quoted in that address; and as, on reference to these, neither of them appears to me at all to touch the question, and as I apprehend that the precise view, to the first promulgation of which amongst geologists I lay claim, seems to me (from this) to be still in some degree misconceived or forgotten, I beg to state, in two simple and distinct propositions, what this view is:—



It is commonly an admitted fact amongst all geologists, that the dry land, such as we now find it, consisting of a continuous rocky

skeleton, with a more or less complete covering of discontinuous or detrital matter over its lower portions, began to be elevated above the sea-level, with the rocky portion bearing still upon its face all that loose detrital mass which had formed upon the rocky bottom (by whatever means) while below the sea-level. A large portion of this detrital covering has been at some time, and in some way, *subsequently* removed.

First, then, if, in the above diagram, $a\,b\,c$ represent the rocky skeleton of such land in progress of elevation above the sea level $D\,E$, and $f\,g^3\,h$, be the coating of discontinuous detrital matter elevated with it:—then I affirm, that one of the most important elements in the mechanism of motion by which this coating will be removed from the elevated land, or from its higher portions, and passed downwards into the plains, or farther again out into the sea, beneath the new or permanent horizon, will be the formation of successive parallel roads, bars, or beaches, as at the points g, g^1, g^2, g^3, g^4, assumed as successive lines of temporary coast line, and within the limits of wave and tidal action, and that successive slippages or slidings out, *en masse*, of loose material, such as sand, mud, gravel, or earth, often bearing large boulders, will continually take place along every such coast at the points marked x and y, at the steep taluses formed along them by the tidal or wave action; and that the distribution of the materials thus descending from above will again produce other similar slippages, at such points under water as those marked z; and that these occur on slopes (of supporting rock) of very moderate inclination, and produce upon the subjacent rock the phenomena of scratching and furrowing, rounding, &c., and in general simulate all the principal traces of glacier action, for which, and for evidence of a supposed arctic or glacial period I consider they have been frequently mistaken.

This subject, which has occupied my mind for some years, and the fundamental proposition of which, as above, was first broached by me to Professor John Phillips, as long ago as when he was Professor of Geology in the Dublin University, and was also publicly promulgated by me at the last Cambridge meeting of the British Association, in the section of Geology, when Professor Sedgwick was in the chair, in the discussion upon a paper by the Rev. J. Cumming, on the Traces of Drift Ice in the Isle of Man, on which occasion I first gave the name of "mud glaciers" to all such masses of slipping materials,

whether under water or above water,—is, I believe, one of importance, and pregnant with results of high value and interest to physical geology, and I trust to be able to complete my long intended task of laying a paper, fully developing my views upon the subject, before the Society when it meets again.

My second proposition is but a corollary to the first, namely—

That around all the existing coasts the formation of such masses of loose material, and their continuous or intermittent slippages, are in daily progress, and that the grooving and furrowing of rocks beneath is now taking place thereby, and the transport within such masses of large boulders detached from sea-cliffs, which are thus gradually transferred out into deep water, and often to vast distances over the floor of the ocean, whence they would emerge and be left isolated, if at a future time such floor should become dry land.

If these two propositions be true, it follows that the rock scratchings throughout the globe will be found hereafter to have been formed by, and to represent the resultant directions of descent of the vast masses of detritus thus moved over them,—moved not by any *debacle*, or by any process of *sweeping away*, surface by surface, or of *cutting* away by *current* action of water, which are the commonly received notions of denudation, but moved bodily and *en masse*, by a *vis a tergo*, namely, the weight of the mass itself, of loose material, acting as a semi-fluid or plastic body, bearing and carrying along with it included solids (boulders, stones, &c.).

These are the views to the origination of which I lay claim, here stated, however, in the most bare and unillustrated way. I have no intention of entering into their merits at present; whether they be true or false, valuable or valueless, is not the point for which I trespass upon the Society, but simply to re-assert my claim to be the originator of them.

I am unable to find any trace of such views as above stated, and as also stated in my letter, before referred to, of December last, in any geological author, and the two authors referred to by Colonel Portlock do not allude to the same subject at all.

The first is M'Culloch, in his System of Geology, vol. ii., p. 368, 369, on "Alluvia of Descent." A reference to this passage, taken in connexion with the whole of the preceding and following pages, on the subject of alluvia or diluvia, will prove to any candid reader,

that the author means by "alluvia of descent," alluvia transferred downwards, *particle by particle*, on slopes of *already elevated land, by the action of rain.* This passage, therefore, does not touch the question at issue, nor can I find a trace of a notion similar to mine (as already stated) throughout M'Culloch's work.

The other passage referred to is by Agassiz,* and is still further from the point—"Et l'on a prétendu que *des courans* de boue chargès de graviers pourraient seuls avoir produit de semblablés effets."

The author here is speaking of the possible causes, other than glaciers, of the scratching and grooving of rocks, and alludes to the passage of mud and gravel, *carried* over the surfaces of rocks by *currents "des courans" of water*, and he rejects these as a source of scratching altogether. He is, therefore, not speaking of the movement by slippage or sliding, *en masse*, of wet and plastic loose material, in virtue of its semi-fluid properties, but of solid matter *propelled* along by currents of water; and, moreover, he rejects the view he refers to, whatever it may be, as a cause of scratching and grooving. Hence, neither does Agassiz touch the subject to which I lay claim.

These are the only two authorities quoted against me by Colonel Portlock, as I understand; and as both of these appear to me to fail in substantiating the slightest anticipation of my peculiar views, I must deem myself still their first originator; and while certain that Colonel Portlock would not knowingly deprive any fellow-labourer in science of whatever credit justly may belong to his investigations, I must regret that, upon an imperfect knowledge, apparently, of what the precise nature of my views were, he should have committed the formal weight of the passages before referred to in his presidential address, in denial of my right of priority of origination, upon grounds which really do not bear upon the matter at all.

APPENDIX.—EXTRACTED FROM THE MINUTES OF THE SOCIETY.

(No. 1.)

Minute of Wednesday, Nov. 12, 1845.

"Mr. Mallet then read an introductory notice on the movements of the gravel beds and of erratic boulders, in which he maintained that these movements were not due to any general diluvial wave or current, but to ordinary forces of water caused by elevation of the land."

* Etudes sur les Glaciers, First Edit., 1850, p. 196-197.

(No. 2.)

Mr. Mallet's Letter to Professor Oldham, communicated to the Society by Professor Oldham at the Meeting of the Society, Dec. 10, 1850.

"DUBLIN, *December* 7, 1850.

"MY DEAR SIR,—The increasing importance which geologists are beginning to attach to the movements of the loose material forming part of our earth's crust, and the identity of view, held and promulgated recently by many, as to one particular question relative to these movements, with those which I myself long since ventured to assert, but which have, I believe, not been very generally known, and certainly have been reproduced in several cases without acknowledgment or reference to the original author or discoverer, induce me, by the present communication, to take date, once for all, as to my own claim (whatever may be its value) to be the original discoverer and first publisher.

"In the latter end of May, 1844, you and I made a geological examination of some parts of the calp cuttings of the Drogheda Railway, in the neighbourhood of Killester. We observed numerous scratchings of the rock *in situ*, and of the lower surfaces of boulder masses, imbedded in the clay and gravel beds above it. I pointed out to you on the spot the evidence that led me to conclude that much of the superincumbent clay had been forced '*en masse*' *up hill* over inclined calp beds. We brought home some specimens of scratched faces of rock, and subsequently I caused some pretty large scratched boulders to be carted away, and deposited them in the Museum of the Geological Society previously to our next Council meeting, which was held on the 5th June, 1844, and at which Professor Phillips was present, to whom I communicated my views, that the scratches which we had observed together had been caused by the movement *en masse* of the clay and gravel beds over the rock beneath, and that the scratches upon the latter, as well as those upon the large boulders reposing on the rock and imbedded in the clay, had been produced by their being carried over the rock along with the moving masses of clay and gravel, &c.

"On the 12th November, 1845, I read the first part of a substantive paper on this subject to the Geological Society of Dublin, in which, having enlarged my observations at Killester by many others in various other and distant localities, I ventured to enunciate the doctrine, that the lateral movement of masses of mud, sand, and gravel, while in a wet and plastic state, either under the sea, or upon land very recently elevated above it, had been the great agent, not only in the almost universal scratchings observable upon the surface of the rocks of every part of the earth, but had been also the means of transport of the far larger proportion of the boulders and greater drift masses that cover the earth. I showed the close similarity that exists between the motions internal and external of a moving mass of mud or sand, and gravel, or of vast landslips, and of those of glaciers; and at the Cambridge meeting of the British Association, on occasion of the discussion in the Geological Section of a paper on the Scratched Rocks of the Isle of Man, I referred them to the movements of such 'mud glaciers,' a view which Professor Sedgwick, the President of the Section, coincided in.

"I have, at subsequent periods, frequently alluded in discussion to this view, and greatly regret that other avocations have as yet prevented my developing the important consequences which I believe can be shown to follow from this peculiar move-

ment of loose material, considered as a general cosmical force, perpetually acting round every coast, at the present day, and having acted on a perhaps still grander scale at former periods of great elevations and depressions, above and below the ocean.

"I believe that the lateral movements due to gravitation of masses of loose material, whether mud, sand, gravel, or all of these, mixed with boulders, will, when combined with the acknowledged agency of elevation and depression, and with the already ascertained laws and known effects (as we observe them now) of tidal action, and those of the motions of fresh-water precipitations over the land, be found a sufficient mechanism to account for the transport to any distance of drift and boulders, and be ultimately admitted, as *the vera causa*, the appointed agents for such removal; and that glacial action, whether of floating icebergs, of drift ice in rivers or estuaries, or of glaciers, although it may be, or have been, an occasional and accidental agent in such transport, and in producing scratches which are evidence of it, have yet not been the main or even important agent in that which constitutes one of the vastest phenomena that our earth's surface presents, namely, the transport, by natural agency, of loose material over it.

"Should these views hereafter be found correct, as I firmly believe they will prove to be, many investigators will be found, as in every generalization, to have had some notion, more or less near to the truth, though not the truth itself, and as in every such case many claims to priority of discovery arise which are hard to investigate, and troublesome to consider, but which the parties interested are naturally anxious should be determined, I am desirous now to claim, in a formal manner, whatever share may justly belong to me as the first (so far as I know) to form and publish the ideas which I have in the preceding lines very imperfectly stated.

"I am anxious to do so now, and in the present form of a letter to yourself, because you were my companion and joint investigator at their very origin, have known the periods and terms in which I have affirmed my views, and have, I am glad to say, given them, to a great extent, your own sanction. Will you, therefore, as I shall not be able to present myself at the next meeting of the Geological Society of Dublin, communicate this letter, or such portion of it as you deem best, to the meeting; and oblige,

"Yours very sincerely,

"ROBERT MALLET."

Note by Mr. Mallet—March 3, 1852.

The passage in Colonel Portlock's Notice of Scratches upon the Rocks of Bantry Bay,* which has induced the publication of the preceding documents, is as follows:—"It appeared to me that these scratches passed under the clay" (i. e. of the bluff headlands of boulder clay resting on scratched schists), "and my impression is, that the whole mass must have moved onwards, and that the pebbles that produced the scratches were imbedded in the clay." This is not a mere statement of a fact: it is also that of a theory to account for the facts.

My letter, as above, to Professor Oldham, 7th December, 1850, did not allude more specially to Colonel Portlock than to other authors. He has, however, thought proper

* Jour. Geol. Soc. vol. v. page 111.

to apply it individually; and in his Annual Address (of February, 1851) endeavours to defend himself from the self-imposed charge of plagiarism by attempting to show—

1. That my views as to movement of detrital masses had never been distinctly enunciated, or even clearly thought out by me.

2. That, according to his conception of my views, they were not new, and had been anticipated by former writers, differing, in fact, in nothing from all common views as to detrital movements.

3. That I had in some way altered, or changed, or extended, the expression of my views since their first promulgation, which, it is inferred, were never committed to published documents.

It has been unfortunate for one whose views have thus been subjected to *ex cathedra* criticism that this Annual Address never made its appearance in print, or in the hands of the members of the Society, until many months after the date of its delivery. It then appeared, with the addition of a note at page 109, which I have reason to believe formed no part of it when delivered to the Society.

The whole question of personal importance turns upon, whether—firstly, this doctrine of movement *en masse* of detritus had been ever clearly enunciated by me anterior to 18th November, 1850, when Colonel Portlock's paper was read; secondly, was the doctrine then original with me, or had it previously been enunciated clearly and distinctly by any other person.

The following passages, extracted from my own Presidential Addresses to the Society, will, I think, fully sustain my claim in both respects:—

"While I fully agree with Captain James in his view, that these marine deposits were precipitated in a tranquil sea, the tranquillity of which was due to the high lands then above the sea-level to the north and west, I can by no means subscribe to the prevalent doctrine of some one or more cataclysmal deluges having swept over the whole of the then submerged surface of Ireland, and convulsively carried along the so-called Northern Drift. On the contrary, I am impressed with the conviction, that the deposition of these tertiaries was due to the long-continued and comparatively quiet action of the tides and marine currents of the ancient ocean, acting upon the detritus of still more ancient lands, combined with the then active motions of elevation by which our island has been raised to its position above the sea-level. I would further venture to express my belief, that future and not distant researches will show that the ordinary motions of the sea in connexion with forces producing elevations of the land, both acting upon the loose materials of which the sea bottom principally consists, and producing therein great and varied movements laterally by sorting and direct transport, *and also by the slipping or movement "en masse" of the beds of loose materials, as mud, gravel, &c., on the inclined beds of rock supporting them, constitute a sufficient machinery to account for all the cases of transport hitherto observed.*"*

"There are few, if any, phenomena producible by the action of glaciers in motion that are not also producible by *aqueous forces acting on mixed masses of detritus of every sort, from mud to boulders, when combined with the slippage of the masses themselves upon their sustaining beds—even to the furrowing, rounding, and scratching of the rocks beneath.*"†

* President's Address, 10th Feb. 1847, p. 9. † Ibid. page 11.

Again, in my Address for 1848 :—

"The next paper was one by myself, in which I have endeavoured to show, that transport to vast distances of boulders or erratic blocks, of almost any conceivable magnitude, may be accounted for by the slow or occasionally rapid movement of semifluid masses of mud, gravel, sand, &c., mixed with those larger materials, when forming the bed of the sea, and either of sufficient depth and mass alone, or resting upon a base of rock, or other materials of very moderate slope, combined with the sorting and transporting power of the tidal currents for the finer materials of the whole mass. That, in fact, the vast accumulations of mud and sand, &c., involving all sorts of heterogeneous materials which constitute the great mass of the sea bottom, must, around the shores at any given time, be in constant motion outwards, forming what I have elsewhere called *mud glaciers*—a somewhat anomalous but expressive term. That these masses, reduced in water to nearly one-third of their weight, will move gradually on slopes of three or four degrees, or even less, and that when the length of plane is as enormous as it in many instances appears to be in the ocean bed, when fresh materials are constantly added to the finer mass by tidal estuary deposits, and fresh blocks supplied by the fall of rocky masses from shore cliffs, and when the outer edge or talus of such banks, going into deeper water, is continually sorted and removed by tidal or oceanic currents crossing the line of slippage, or motion of the mass, transport of the contained blocks may be accounted for to vast distances, and taking in the element of successive elevation of land, and hence of new shores, being pushed further and further out, that this machinery alone is sufficient to account for transport of blocks to an indefinite distance.

"The actions of breaking waves in shallows and on shores have been much confounded with those of the unbreaking waves of translation. The former are incessantly at work. Let their powers and their effects be studied with care, and above all in the clearness of exact science;—let the results of their actions be connected with those of tidal and of ocean currents, as now known to exist, and connected also with such gradual or *per saltem* elevations or depressions of the land, above or below the sea, viewed as a fixed horizon, as we have observed;—and lastly, let all these be connected with the movements of loose materials going on in the existing sea bottoms, by the fluency or semi-fluid motions of these vast masses of matter, reposing on inclined beds, which beds are themselves subject to changes of inclination, as well as to elevation and depression;—and from the whole I am bold enough to venture a prediction, that no phenomena of transported materials, however vast, have yet been observed, that such a machinery will not be found sufficient to account for. In these, I believe, will be found the *vera causa* of northern and other great drifts—to the passage of these mud glaciers (to use this term again) over surfaces of rock below the sea, may be traced the furrows and groovings as to which so much has been written, but which are now at length admitted to have been produced principally under water, and in all possible directions, neither universally accordant with tidal nor with glacier directions of motion, but with the slope of the rock beneath; and to these shore or breaking waves may be attributed those gigantic cauldrons (the Riesenötpfe) of the Scandinavian rocks, which neither glaciers nor icebergs can throw any light upon.

"But while I state my conviction, that the connecting forces above stated will

yet be found to be the true and general cause of drift transport, I readily admit that icebergs cast afloat have been, as they are now, an occasional means of transporting a freight of foreign rocky and other matter to vast distances; and may have been the carriers of many of our boulders found isolated to great distances from their originating rocks; but their powers seem quite inadequate to the gigantic task that has been affirmed of them as the universal drift carriers. The great operations of nature are always performed by forces steadily in action, yet others, only called occasionally, or, as it were, accidentally, into play, do sometimes subordinately act in concert with, and, as it were, simulate the functions of these; and the remarks of Mr. Milne on this subject, as referring to the drifted materials of Scotland, seems to be conclusive, that iceberg action may here, at least in part, have been the carrying agent."*

Upon these quotations I rest the issue of the claim that I here again make of having been the first to promulgate the doctrines they enunciate. They prove that my views were from the outset clearly stated, and therefore clearly conceived, and that from their first publication in 1844 to the present hour I have neither altered, changed, nor added aught to their statement.

It is with pain, therefore, that I feel compelled to notice as unwarranted the charge (so grave if it were true) to be deduced from the following sentence of Colonel Portlock's Address:—"I have endeavoured to represent it as I conceived it to have been delivered *originally* by its author, *but he now states* that he intended to extend the principle of slips to detrital matter under water."† The Italics are mine.

How far these views of mine are original, and how far, if at all, they have been anticipated by those of other and former writers, geologists will decide for themselves. Whether Colonel Portlock has understood or misunderstood my views, it is not for me to discuss; but I must continue to believe that he has not yet grasped the leading idea of them, for I have too high a respect for him to suppose that otherwise be would have laboured through pages 63, 64, 65, 66, *et seq.*, in endeavouring to show identity between my views and those of M'Culloch, Dausse, D'Halloy, and others, with which they have not the remotest similarity or connexion, as any reader of the whole originals, *with their contexts*, cannot fail to find.

As to Colonel Portlock's present opinion of the value, or want of value, of these views of mine, I can afford to wait. Meanwhile, geologists will, no doubt, receive with caution any opinion the author of which professes to have adopted it from "any vague perception," and I feel assured that in time to come Colonel Portlock will entertain clearer notions, and, in common with many other geologists, distinguished as he so justly is, will recognise with me the importance to geology of movements *en masse* of detrital deposits.

I have felt compelled, though with much reluctance, to add the preceding note to my communication, in consequence of the matter introduced subsequently to the delivery of the President's Address; but here, so far as I am concerned, the controversy shall end. Life is too short, the value of an unruffled spirit too great, to waste it in discussion one moment after it ceases to be on all sides an earnest seeking after truth alone.

* President's Address, 9th Feb. 1848, pp. 18, 19. † Ibid. page 109.

November 12, 1851.—"Notes on the Geology of Rathlin Island;" by the Rev. Samuel Haughton, M. A., Professor of Geology in the University of Dublin.

Mr. Haughton described the relations between the chalk and overlying basalt observed by him during a recent visit to the island of Rathlin. The account of the geology of the island was accompanied by diagrams and maps illustrating the structure of the basalt of the island. The woodcuts accompanying the present notice of Mr. Haughton's paper are reduced from larger views of sketches taken on the spot.

On inspecting the accompanying map of the island (fig. 1), it is apparent that the island is composed of basalt resting upon chalk, which only appears at intervals round the sea-coast, lying underneath the mass of tabular and eruptive trap which has been poured over the surface of the island, as in the adjoining districts of the main land.

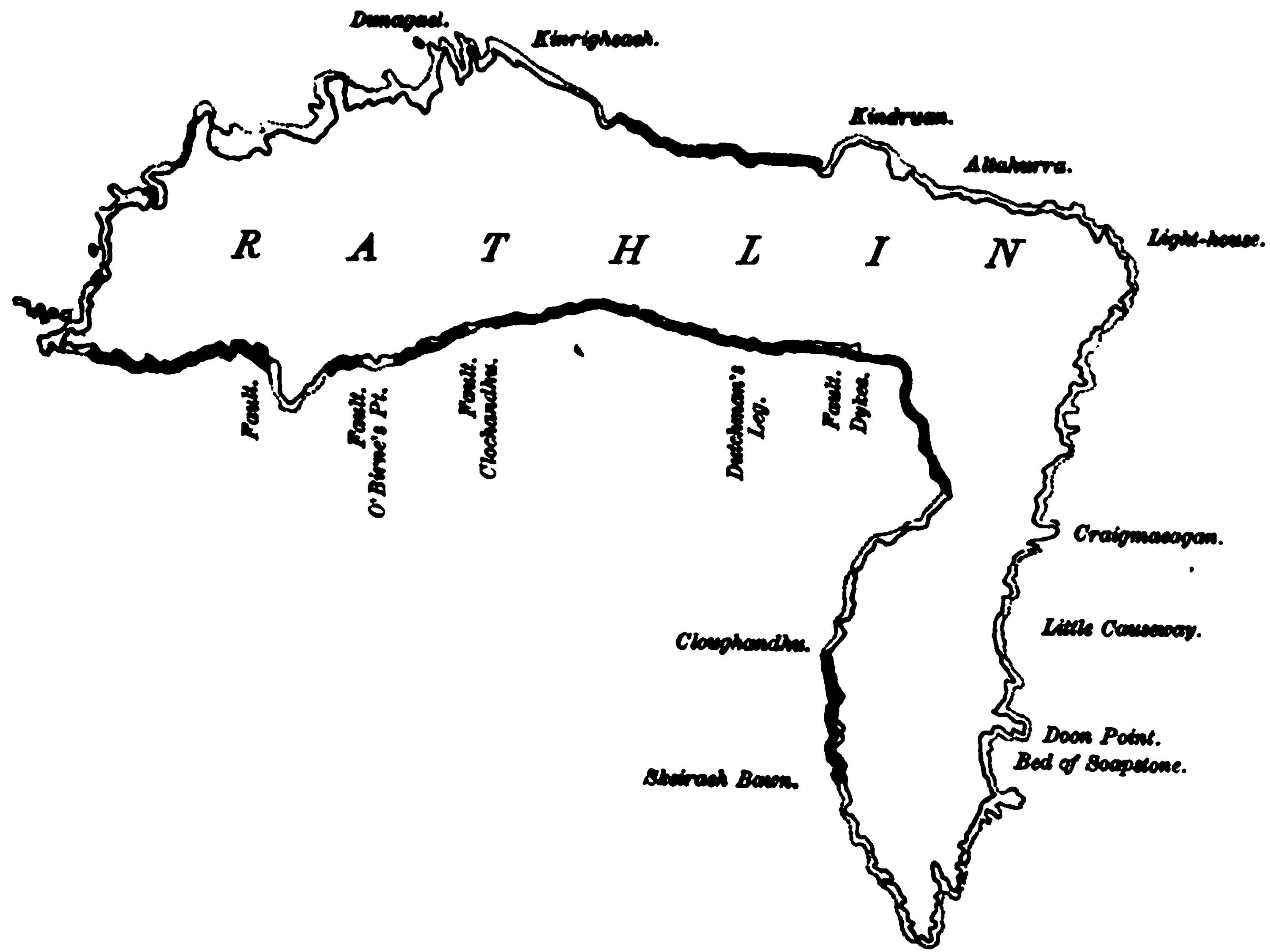
Commencing at Kindruan Head on the north, which is composed of massive and tabular basalt, rising to the height of 375 feet, and resting on the west upon a ledge of chalk rocks, which do not rise above the sea-level, and proceeding eastward along Altahurra Bay, the trap gradually diminishes in height, until, at the lighthouse at the north-east point, it only rises to a height of 178 feet above the sea-level. The trap forming the cliff on which the lighthouse is built is tabular, and the sheets dip south-west.

The whole of the east coast of the island is composed of basalt, not rising, in general, above 80 feet, sometimes tabular, having its beds separated by two or three thin layers of ochre; and sometimes, as at Craignacagan and Doon Point, the basalt exhibits a columnar structure of the most singular and apparently irregular arrangement. At the former place the columns are arranged vertically, and these are capped by another series of smaller columns inclined at various angles to the former.

About half-way between Craignacagan and Doon Point the remarkable fan-shaped arrangement of basaltic columns represented in fig. 2 occurs. It is called the Little Causeway, and nothing can exceed the irregularity of the directions of the pillars in the portion represented in the sketch; the general arrangement is vertical, but every variety of inclination occurs, from horizontal to vertical.

Figure 3 represents a view of Doon Point from the south, and of the curiously curved columns of basalt which form the northern

Fig. 1.



GEOLOGICAL MAP OF RATHLIN ISLAND

The unshaded portion of the Island is Basalt. The shaded portion, round the sea-coast, is Chalk.

Fig. 2.

THE LITTLE CAUSEWAY, EAST COAST OF RATHLIN

Fig. 3.

VIEW OF DOON POINT, FROM THE SOUTH

boundary of the Bay to the south of the Point. The curvature of some of the pillars is continuous through 90°, and they pass from the vertical to the horizontal position, exhibiting, however, a tendency to break at the point of greatest flexure, which has caused most of them to be broken off by the action of the sea.

The Bay south of Doon Point contains beds of ochre and soapstone, the latter contained in amygdaloidal cavities of decomposing trap; the bedding of both is conformable to that of the tabular trap.

The basalt continues without interruption round the southern point of the island, to the point marked Skirach Bawn, or the White Rock, where it rises to the height of 218 feet, and rests upon ledges of chalk, which crop out from under it at the sea-level, and continue as far as the point called Cloughandhu, or the Black Rock, when the trap again covers up the chalk, which does not again appear until we reach the south side of Church Bay, a few yards to the north of the mill. The chalk constitutes the shores of Church Bay, and continues, with the interruptions marked on the map, to the western point of the island, called Bull Point. The chalk reaches its highest elevation along the line of cliffs running from Church Bay to Bull Point, and sometimes rises to one-third of the height of the cliff, being, however, always surmounted by tabular basalt.

There is a remarkable fault, accompanied by basaltic dykes, running N. S. up the valley, immediately to the west of the church. These dykes are described by Messrs. Conybeare and Buckland.* The measurement of the three dykes which are visible on the shore, reckoned from east to west, as given by Messrs. Conybeare and Buckland, is as follows:—

First, or eastern dyke, 20 feet; second, or middle dyke, 1 foot; third, or western dyke, 35 feet; the interval between Nos. 1 and 3 being 20 feet.

The measurement of these dykes obtained by Mr. Haughton is somewhat different, being probably taken at a different point:

Eastern dyke, 29 feet (approximate measurement, in consequence of the dyke being partly covered by the shingle).

Middle dyke, 3–4 feet.

Western dyke, 94 feet; becomes thinner as it runs south towards the sea.

Breadth of chalk between eastern and western dykes, 121 feet.

* Trans. of the Geol. Soc. of London, vol. iii. p. 210.

These three dykes bear N. 5° W., which line, if prolonged to the south, would intersect the Ballycastle collieries, for which reason Mr. Haughton is inclined to connect the dykes in Church Bay with the system of dykes belonging to Fair Head, and not with the dykes of Kenbawn Head, as proposed by Messrs. Conybeare and Buckland.

In order to verify this connection, Mr. Haughton measured the bearing of the four principal dykes of the Ballycastle colliery, and found them, proceeding from east to west, as follows:—

Carrickmore dyke	bears	N. 10° E.
Pollard dyke	„	N. 15° W.
West Mine dyke	„	N. 10° W.
North Star dyke	„	N. 5° W.

The beds of chalk in Church Bay are nearly horizontal, but dip slightly N. 10° W.

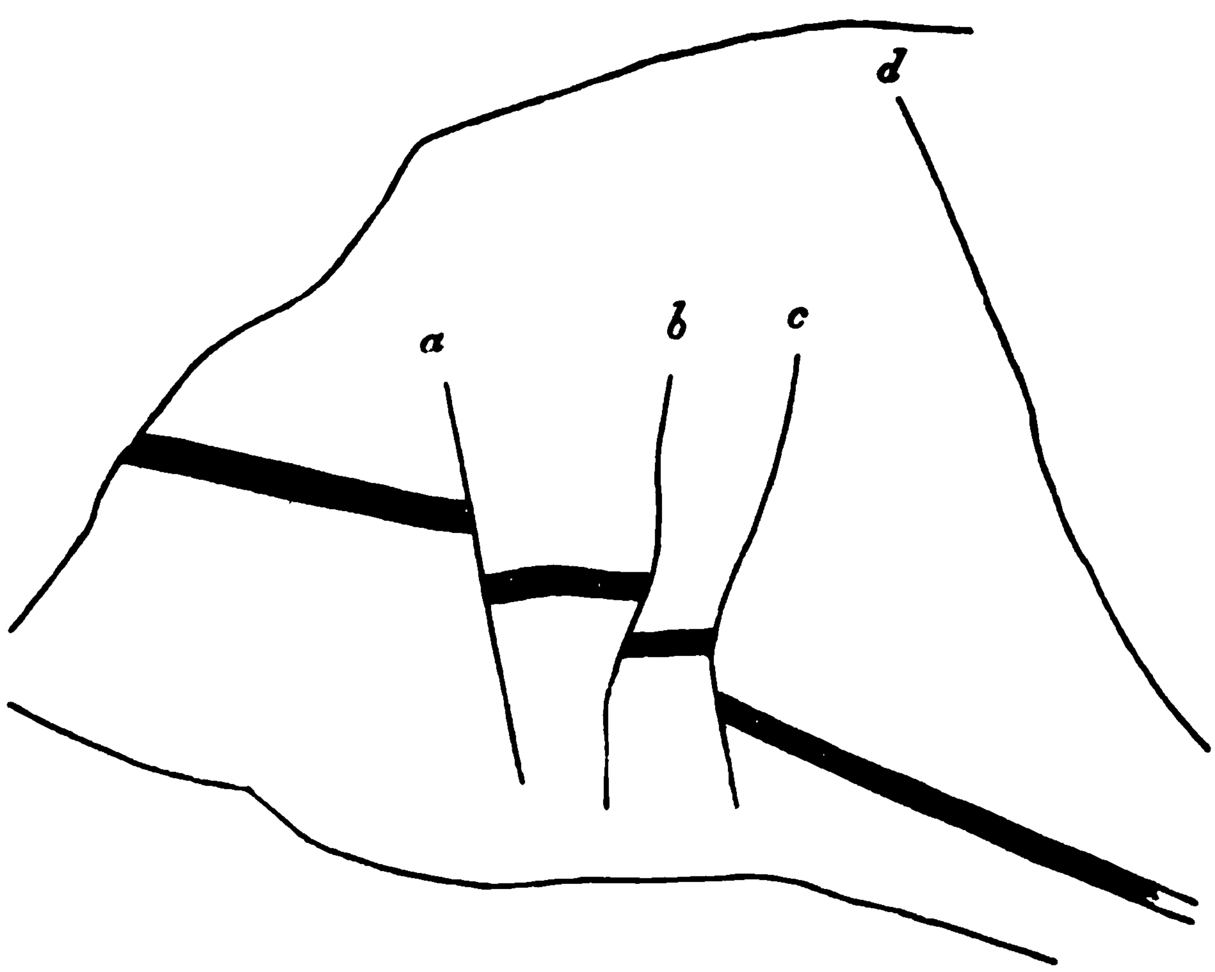
The downthrow of the fault accompanying the dykes at the church is to the eastern side. The chalk is, as usual, altered into a blue crystalline limestone, by contact with the dykes.

A few yards to the east of the dykes there occurs a section of the vein of basalt penetrating the chalk, which is represented in plan in the annexed woodcut, in which the shaded portion represents basalt, and the unshaded portion the chalk through which it penetrates.

Between Church Bay and Bull Point, the chalk is interrupted in the cliffs three times by the occurrence of faults, accompanied by

downthrows to the east. The three headlands composed of basalt are called Halfway Point, O'Birne's Point, and Stroandergan; the fault occurs at the western side of these headlands; but there does not appear to be any trace of eruptive trap at these points.

The chalk appears in three places on the sea-level, cropping out from under the basalt, on the north side of the island; these points are marked on the map. From the lower level of the chalk on the northern side of the island, a general dip towards the north of the bed of chalk may be presumed; but the general dip of the masses of tabular trap covering the chalk at the north side of the island is to the south-west. This is particularly observable at Dunagael, where a bed of lignite occurs, from six to ten inches thick, and lying between two thick beds of columnar basalt. To the west of Dunagael lies the headland ralled Kebble Head, on the west side of which the bed of ochre, which separates the masses of tabular trap in the upper part of the cliff, is broken by faults in the manner exhibited in the annexed diagram.



The shaded stratum represents the bed of ochre, broken in three places by the faults *a*, *b*, *c*. This breaking up of the beds of tabular trap after their deposition is universal through the island; the strata are broken by innumerable faults and fissures, which render it difficult to observe the relations which exist between the trap and chalk.

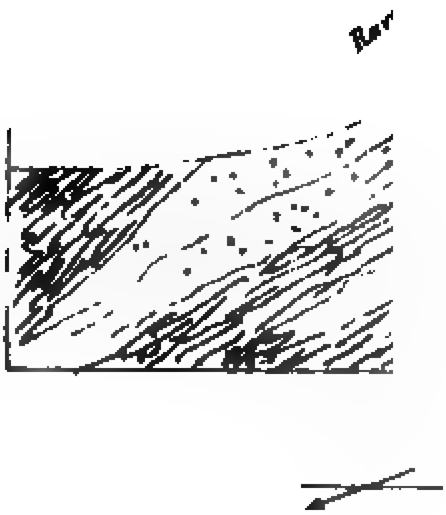
The bed which appears in Altahuile Bay, west of Kindruan, is the most extensive development of the chalk on the north side of Rathlin.

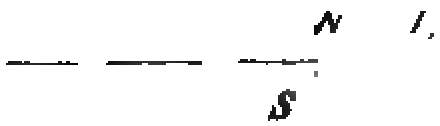
December 10, 1851.—"Upon the composition of a new variety of metallic ore, from the Vale of Ovoca, County of Wicklow;" by James Apjohn, M.D., Professor of Chemistry and Mineralogy, Trinity College, Dublin.

In the course of the past summer I received from George M'Dowell, Esq., one of the Junior Fellows of the University, a mineral substance, which was obviously a metallic ore, with a request that I would inform him of its exact composition. This mineral, which he described as constituting a central mass or nucleus within a newly discovered lode, or bed of sulphur ore, in the Ballymurtagh district, was massive, of a leaden colour, with tinge of brown, and exhibited numerous intermixed particles of yellow iron pyrites. Its specific gravity was found to be 4.4955, and, heated on charcoal by the outer flame of the blow-pipe, sulphur was burnt off, a yellowish-white oxide was deposited on the charcoal, and the ordinary flame being finally applied, a small globule of lead was with difficulty procured.

When acted upon by strong muriatic acid in excess, and at a boiling temperature, sulphuretted hydrogen was disengaged, a portion of the mineral remained unaltered, which proved to be the bisulphuret of iron, or common pyrites, while the *solution*, when tested by the appropriate re-agents, was found to include the chlorides of lead and zinc, and the protochloride of iron.

In effecting the quantitative analysis of this mineral, the same solvent (muriatic acid) was employed, and the bisulphuret of iron which it left undissolved was well washed with boiling water, and, after being dried at 212°, was weighed. The dissolved chlorides were now treated with a little nitric acid, and the solution having been evaporated nearly to dryness, the chloride of zinc and sesquichloride of iron were dissolved out by rectified spirits. The chloride of lead, thus insulated, having been dried and weighed, water of ammonia was added in excess to an aqueous solution of the other chlorides, which precipitated the peroxide of iron, and redissolved the oxide of zinc. The peroxide of iron was now collected on a filter,

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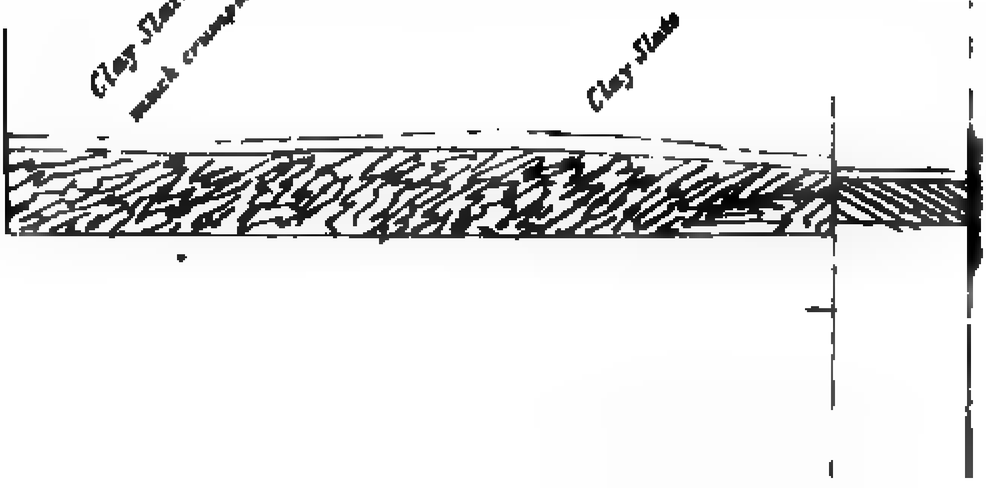

Clay Slate
much crumpled
Clay Slate

and, when well washed, was ignited and weighed; and the ammoniacal solution of chloride of zinc having been evaporated to dryness, the residue was acidulated with sulphuric acid, and after another evaporation, and exposing the residual sulphate of zinc to a low red heat, its weight was accurately taken.

The chloride of lead, sesqui-oxide of iron, and sulphate of zinc being now, by calculation, reduced to sulphurets, the following results were obtained:—

Bisulphuret of Iron, $Fe\ S_2$, ... :	24.97
Sulphuret of Iron, $Fe\ S$, ...	7.33
Sulphuret of Lead, $Pb\ S$, ...	19.13
Sulphuret of Zinc, $Zn\ S$, ...	46.62
	100.00

Neglecting the iron pyrites, which is obviously a mechanical intermixture, the residual constituents are very accurately expressed by the following formulæ:—

$$Fe\ S + Pb\ S + 6Zn\ S.$$

Upon a second analysis the same formula was found to be very nearly applicable, so that, notwithstanding the singularity of the constitution of this mineral, all its proximate constituents being basic sulphurets, I am disposed to consider it as a distinct and definite compound.

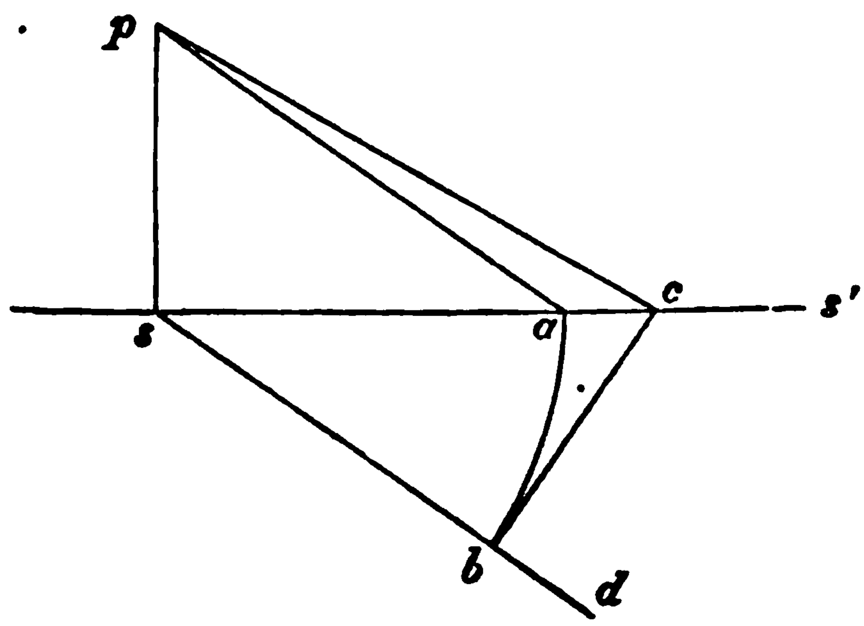
December 10, 1851.

FREDERICK J. SIDNEY, Esq., LL.D., exhibited a map and section made by him, in conjunction with Mr. H. Medlicott, in the neighbourhood of the town of Wexford. The map, comprising sheet 42 of the Ordnance Survey of the county, and the section* being taken from a point N.W. of Carrickadee Rocks to Finoge Bridge, being in a direction nearly N.W. and S.E., and about six miles in length. The limestone in the immediate vicinity of the town is magnesian, alternating with beds of shale. There are several quarries in the neighbourhood, in some of which the limestone is highly crystalline and full of small cavities. In some instances, native sulphur, in a state of great purity, was found in the cavities. The average dip of the limestone is about 25°, towards the S.E. Conformable to the lime-

* Vide section 1, pl. I.

stone is the old red sandstone and conglomerate, which appears on the flanks of the hills, which run in a S.W. direction from the town. The hills are composed of quartz rock, alternating with clay slate, and dipping in the opposite direction to the limestone and old red sandstone, and at a higher angle. A greenstone dyke occurs close to the line of section; the greenstone is wholly decomposed into yellow ochre.

NOTE. The dip, as laid down in the section, is not the actual dip of the strata, the section not being exactly at right angles to the strike, but represents the actual intersection of the plane of the section with that of the beds, and is plotted as follows:—*ss'* being the direction of the section, and *p* the point of observation. Draw *sd*, making the angle *s'sd* = the angle contained between the direction of the dip and that of the section. Make the angle *spa* = the complement of the observed dip. Make *sb* = *sa*, and erect the perpendicular *bc*; *pc* is the line required; the correction for the deviation of the line of section from that of the dip being thus the angle *apc*.



The above construction appears simpler in practice than the method usually adopted, which is by calculation, either with the aid of the sliding rule, or of trigonometrical tables.

January 14, 1852.—"Notes on the Serpentines of Cornwall and Connemara;" by the Rev. SAMUEL HAUGHTON, M. A., Professor of Geology in the University of Dublin.

MR. HAUGHTON communicated the following notes on the Lizard district of Cornwall and the serpentine quarries of Connemara.

At junction of serpentine, with hornblende slate, between Cury and Mullion, dip of slate is 28° W. 40° S., with joint planes, N. 20° E.

At junction at Landewednack, the hornblende rock is separated from serpentine by a stream; dip of hornblende slate, W. 10° S. A

vein of ochreous clay runs through the serpentine at its junction with the hornblende rock.

At the Lizard Head, junction of mica slate with hornblende slate, near lighthouse: dip E. 40° N.

Junction of hornblende slate and serpentine, north-west of Lizard Head, marked by a vein of purple clay; dip of hornblende slate, E. 40° S.

The hornblende slate and mica slate, north of Lizard Point, appear to alternate with each other.

At Mullion Churchtown, junction of hornblende slate and serpentine; dip of slate is W. 10° N.

Veins of steatite and green serpentine occur in the serpentine porphyry, at Kynance Cove. Native copper occurs, with steatite and some carbonate of lime, at Mullion.

I. *Analysis of Steatite, or English Soapstone, from Gue Grease, near Kynance.*

	Per Cent.	Atoms.		Integer Atoms.	
$Si\,O_3$ =	42.10 =	0.939 ...	6.29	6	18
$Al_2\,O_3$ =	7.67 =	0.149 ...	1.008	1	2
$Mg\,O$ =	30.57 =	1.477 ...	10.00	10	21
$H\,O$ =	18.46 =	2.051 ...	13.81	14	29
	98.80				

From the first set of integer atoms, the rational formula would probably be

$$5\{2\,Mg\,O,\ Si\,O_3\} + \{Al_2\,O_3,\ Si\,O_3\} + 14\ H\,O. \quad (1)$$

The second set of integers represents still more closely the results of the analysis, and is identical with the series of numbers deduced by Rammelsberg from Svanberg's analysis of the English soapstone, with the exception of the number of atoms of water.

From Svanberg's analysis, Rammelsberg deduces this rational formula:

$$\{3\,(3\,Mg\,O, Si\,O_3) + 2\,(Al_2\,O_3,\ Si\,O_3) + 3\ H\,O\} + 4\ \{3\,Mg\,O, 2\,Si\,O_3 + 3\,H\,O\} \quad (2)$$

The first formula represents the analysis nearly as well, and has the advantage of being less complicated.

The analysis of Klaproth cannot be reconciled with Svanberg's or Mr. Haughton's.

II. *Analysis of Soapstone from Kynance Cove.*

	Per Cent.	Atoms.	Integer Atoms.	
$Si\,O_3$	= 42.47	0.937	6.78	7
$Al_2\,O_3$	= 6.65	0.129	0.93	1
$Mg\,O$	= 28.83	1.393	10.00	10
$H\,O$	= 19.87	2.152	15.44	15
	97.82			

Hence its formula is—

$$5\{2\,Mg\,O,\ Si\,O_3\} + \{Al_2\,O_3,\ 2\,Si\,O_3\} + 15\,H\,O. \qquad (3)$$

Combining the two soapstones, we find the probable composition:

	Atoms.
$Si\,O_3$ =	13
$Al_2\,O_3$ =	2
$R\,O$ =	20
$H\,O$ =	28

Hence the mean formula is—

$$10\{2\,Mg\,O,\ Si\,O_3\} + \{2\,Al_2\,O_3,\ 3\,Si\,O_3\} + 28\,H\,O \qquad (4)$$

Connemara Serpentines.

The strike of thinly-bedded quartz rocks in the neighbourhood of Mr. D'Arcy's quarry, between Clifden and Moyard, is E.W. Strike of beds of serpentine, or verd antique, which is mixed with masses of purer limestone, is E. 10° S., W. 10° N.

The bedding is rather doubtful, but the strike of the beds is easily ascertained.

III. *Analysis of Serpentine from Ballinahinch Quarry.*

	Per Cent.	Atoms.		Integer Atoms.	
$Si\,O_3$	= 40.12	... 0.885	... 1.000	10	5
$Mg\,O$	= 40.04	... 1.984	... 2.191	22	11
$Fe\,O$	= 3.47	... 0.096			
$H\,O$	= 13.36	... 1.484	... 1.676	16	8
$C\,O_2$	= 2.00	... 0.091			
$Ca\,O$	trace.				
$Al_2\,O_3$	trace.				
	98.99				

The result of this analysis, which was made by the Rev. Joseph A. Galbraith, proves (if the atomic weight of magnesia be 20.1) that the Ballinahinch serpentine corresponds with the formula deduced

by Rammelsberg, as the *mean* of thirteen good results from different localities. Its rational formula is, therefore, according to Rammelsberg,

$$\{2\,(3\,MgO,\,2\,SiO_3) + 3\,HO\} + 3\,\{MgO,\,HO\} \qquad (5)$$

Or, with the usual weight of Mg O

$$5\{2\,MgO,\,SiO_3 + HO\} + \{MgO,\,3\,HO\} \qquad (6)$$

IV. *Analysis of red earthy base of Serpentine Porphyry, from Kynance Cove.*

	Per Cent.
SiO_3 =	38.29
Fe_2O_3 =	15.00
MgO =	34.24
HO =	12.09
	99.62

Converting Fe_2O_3 into Fe O, we find

	Per Cent.	Atoms.	Integers.
SiO_3 =	38.29	0.845	10.00
FeO =	13.50	0.375	24.00
MgO =	34.24	1.654	
HO =	12.09	1.343	15.89

Hence we obtain finally, for the integer atoms:

$$SiO_3 = 5$$
$$RO = 12$$
$$HO = 8$$

The Ballinahinch serpentine gave,

$$SiO_3 = 5$$
$$RO = 11$$
$$HO = 8$$

If only *half* the iron be present in the porphyry as protoxide and the rest as peroxide, mechanically combined, the Cornish porphyry will be identical with the Galway serpentine.

It is worthy of remark that the blow-pipe is sufficient to distinguish the red paste of the porphyry from any variety of feldspar, with which it has been often confounded.

AT THE

ANNUAL GENERAL MEETING

HELD ON

WEDNESDAY, FEBRUARY 11th, 1852,

REV. JOSEPH A. GALBRAITH, F.T.C.D., IN THE CHAIR,

The following Report from the Council was read and adopted:

The Council have to offer to the Society the following Report for the past year.

Seven new members have been added to the Society, viz.:— Joseph Beete Jukes, M. A.; John Irvine Whitty, Esq.; George M'Dowell, F. T. C. D.; Edward Wright, LL. D.; Henry Medlicott, Esq.; Alexander Jack, Esq. (formerly Associate); and Rev. John H. Jellett, Professor of Natural Philosophy, University of Dublin.

The following Associate Members have joined the Society:— George H. Kinahan, Esq.; Arthur A. Jacob, Esq.; John Kennedy, Esq.; John Cogan, Esq.; William Thornhill, Esq.; John K. Reid, Esq.; and Joseph O'Kelly, Esq.

Withdrawn or deceased:—William Hogan, Esq.; A. G. Melville, M. D.; Sir James Murray; Arthur Todd, Esq; Arthur Jacob, M. D.; Franc Sadlier, D. D., late Provost of Trinity College; and Richard Purdy, Esq.

The Society, in common with many other public institutions of Dublin, have to deplore the removal by death of the late Provost of Trinity College, who was one of the oldest members of this Society, and felt much interest in its welfare.

The Society at present numbers: 4 Honorary Members, 35 Life Members, 83 Annual Members, and 10 Associates; total amounting to 132 members.

After due consideration, it was not deemed advisable to renew the offer of prizes for papers contributed to the Society, and your

Council desire to impress upon the members of the Society generally the necessity of relying altogether upon their own exertions, and trust they may next year have to report a large accession to the working members of the Society.

During the past year, your Council have published the First Part of Vol. V. of the Journal of the Society, and trust that the Society will not meet with any disappointment as to the speedy publication of their subsequent Proceedings.

During the past year, the Council have had to contend with serious financial difficulties, arising partly from the negligence of some members in paying their subscriptions in time to enable the Council to carry out fully, by means of cash payments, their plans of financial reform. They trust, however, that this is the last time they shall be obliged to report difficulties of this description.

The Treasurer's account, as annexed, shows a balance due to the Treasurer of £26 *5s.* 10¼*d.*

The following list contains an account of the Donations made to the Society during the past year.

DONATIONS

RECEIVED SINCE LAST ANNIVERSARY.

1851.

March 4.—Quarterly Journal of the Geological Society of London, No. 25. Presented by the Society.

May 7.—Address to the Geological Society of London, 21st February, 1851, by Sir Charles Lyell, F. R. S., &c. Presented by the Author.

May 21.—Tabular View of the Order of Deposition, &c., of the principal European Groups of Stratified Rocks, by Capt. R. Smith. Presented by the Publisher, Mr. Samuel B. Oldham.

May 21.—Geological Maps of the Counties of Dublin and Wexford. Presented by the Chief Commissioner of Woods and Forests, through Sir Henry T. De la Beche.

June 4.—Quarterly Journal of the Geological Society of London, No. 26. Presented by the Society.

June 9.—The Mining Journal, No. 823. Presented by the Editor.

June 9.—Twenty-third Annual Report of the Bristol Institution. Presented by the Institution.

June 27.—Transactions of the Institution of Civil Engineers, Vols. I. to III.; Minutes of Proceedings, Vols. I. to VI., with portions of Vols. VII. to IX.; List of the Members, and a new Catalogue of the Library. Presented by the Institution.

Aug. 21.—Quarterly Journal of the Geological Society of London, No. 27. Presented by the Society.

Sept. 19.—Transactions of the Kilkenny Archæological Society, for the year 1850. Presented by the Society.

Oct. 20.—Researches in Terrestrial Physics, by Henry Hennessy, M. R. I. A. Presented by the Author.

1851.

Oct. 30.—Proceedings of the Royal Irish Academy, Vol. IV., Part 3, and Vol. V., Part 1. Presented by the Academy.

Nov. 12.—The Mining Journal, No. 846. Presented by the Editor.

Dec. 3.—Quarterly Journal of the Geological Society of London, No. 28. Presented by the Society.

Dec. 8.—Lithograph of a Cork tree (*Quercus suber*), now growing at Summerstown, near Cork. Published for the Cork Cuvierian Society, and presented by them.

Dec. 24.—Museum of Practical Geology.—Government School of Mines and of Science applied to the Arts. Inaugural Discourse at the opening of the School, 6th November, 1851, by Sir Henry T. De la Beche. The Relations of Natural History to Geology and the Arts, by Edward Forbes. On the importance of cultivating Habits of Observation, by Robert Hunt; and, On the National Importance of studying Abstract Science, with a view to the healthy Progress of Industry, by Lyon Playfair. The whole presented by Sir Henry T. De la Beche.

1852.

Jan. 1.—Report of the British Association for the Advancement of Science, for 1850. Presented by the Association.

Jan. 7.—Journal of the Royal Geographical Society of London, Vol. XXI. (1851). Presented by the Society.

Jan. 14.—The Athenæum, June to December, 1851. Presented by the Editor.

Jan. 14.—The Literary Gazette, 1851. Presented by the Editor.

Jan. 14.—Specimens of Lithodendra and other Fossils, from Lough Gill, County Sligo. Presented by John Wynne, Esq., Hazlewood, County Sligo.

ADMISSION FEES.

	£	s.	d.
Henry Head, M. D.,	1	0	0
J. I. Whitty, Esq.,	1	0	0
J. B. Jukes, Esq.,	1	0	0
R. Hitchcock, Esq.,	1	0	0
E. Wright, Esq.,	1	0	0
Lord Talbot de Malahide,	1	0	0
	£6	0	0

SUBSCRIPTIONS.

	£	s.	d.
Rev. J. Galbraith,	1	0	0
John Patten, Esq.,	1	0	0
W. T. Mulvany, Esq.,	1	0	0
Thomas Maguire, Esq.,	1	0	0
Doctor Harrison,	1	0	0
M. D'Arcy, Esq.,	1	0	0
A. M. Giles, Esq.,	1	0	0
J. Petherick, Esq.,	1	0	0
Thomas Hutton, Esq.,	1	0	0
Colonel Portlock,	1	0	0
J. G. Medlicott, Esq. (1850),	0	5	0
J. G. Medlicott, Esq.,	1	0	0
F. W. Burton, Esq.,	1	0	0
J. G. Nicholson, Esq. (1850–1851),	2	0	0
Thaddeus O'Mahony, Esq.,	0	5	0
Doctor MacDonnell,	1	0	0
S. Downing, Esq. (1850–51),	2	0	0
T. M. Hutton, Esq., do.	2	0	0
H. W. Allen, Esq.,	1	0	0
Dr. H. Head,	1	0	0
Professor Allman,	1	0	0
Robert Callwell, Esq.,	1	0	0
Thos. Hamilton, Esq. (1850–1851),	2	0	0
A. Jack, Esq.,	0	5	0
J. I. Whitty, Esq.,	1	0	0
Carried forward,	£26	15	0

	£	s.	d.
Brought forward,	26	15	0
F. J. Sidney, Esq.,	1	0	0
William Edington, Esq.,	1	0	0
F. M. Jennings, Esq. (1850–1851),	2	0	0
Lord Talbot de Malahide,	1	0	0
Dr. Jacob,	1	0	0
B. D. Gibbons, Esq. (1849–1850–1851),	3	0	0
William Dawson, Esq.,	1	0	0
E. Dawson, Esq.,	1	0	0
J. Welland, Esq.,	1	0	0
Thomas Brien, Esq.,	1	0	0
Dr. R. Ball,	1	0	0
Richard Griffith, LL. D.	1	0	0
Rev. Dr. Wall,	1	0	0
C. P. Croker, M.D.,	1	0	0
P. Byrne, Esq. (1850-51),	2	0	0
A. M. Giles, Esq.,	1	0	0
John Radcliffe, Esq.,	1	0	0
R. Hitchcock, Esq.,	1	0	0
Rev. S. Haughton,	1	0	0
John Purser, Esq.,	1	0	0
Dr. Apjohn (1850-51)	2	0	0
E. Wright, Esq.,	1	0	0
Dr. Harvey,	1	0	0
Dr. Duncan,	1	0	0
	£55	15	0

ABSTRACT OF TREASURER'S ACCOUNTS FOR THE YEAR ENDING FEBRUARY, 1852.

Dr.

		£ s. d.
To Balance of last year's Account,		29 13 10½
— Admission Fees,	£6 0 0	
— Subscriptions,	55 15 0	
		61 15 0
— Received from Mr. Oldham for Journals sold,	2 2 6	
Do. do.,	0 5 6	
		2 8 0
— One year's Interest to 5th January, 1852, on £80 12s. 8d., 3¼ per Cent. Stock,		2 12 4
— Balance due to Treasurer,		26 5 10½
		£122 15 1

Cr.

			£ s. d.
1851.			
April 2.	—By paid Mr. Oldham's Account for Printing, &c.,	£68 5 3	
	— Servant in charge of Room,	1 10 0	
	— Porter's Wages,	2 0 0	
	— For Advertising, and small expenses,	0 13 6	
			72 13 9
Nov. 5.	—By	£10 0 0	
	—	12 10 11	
	— Mr. Oldham's Account for Printing, &c., (Per Draft 8811)	6 13 0	
			29 3 11
1852.			
Feb. 4.	—By paid Assistant Secretary's a- rt.,	£10 0 0	
	— , per book,	4 16 0	
	— Mr. Oldham's Account, (Per Draft 8812)	2 19 8	
			17 15 8
	— By Collector's Poundage,		3 1 9
			£122 15 1

11th February, 1852.

WILLIAM EDINGTON, *Treasurer.*
JOSEPH A. GALBRAITH, *Chairman.*

The following Officers for the ensuing year were then declared duly elected, and the Society adjourned to receive the President's Annual Address:—

President:

ROBERT BALL, LL.D.

Vice-Presidents:

HUMPHREY LLOYD, D.D., S.F.T.C.D.

THE ARCHBISHOP OF DUBLIN.

LT.-COLONEL PORTLOCK, R.E.

ROBERT MALLET, C.E.

PROFESSOR ALLMAN, M.D.

Treasurers:

WILLIAM EDINGTON, ESQ.

SAMUEL DOWNING, C.E.

Secretaries:

REV. S. HAUGHTON, F.T.C.D.

FREDERICK J. SIDNEY, LL.D.

Council:

JAMES APJOHN, M.D.

RICHARD GRIFFITH, LL.D.

C. W. HAMILTON, ESQ.

JOHN MACDONNELL, M.D.

PROFESSOR HARRISON, M.D.

THOMAS HUTTON, ESQ.

ROBERT CALLWELL, ESQ.

PROFESSOR HARVEY, M.D.

REV. J. GALBRAITH, F.T.C.D.

JOHN KELLY, ESQ.

JOHN PETHERICK, ESQ.

JOHN KING, ESQ.

RIGHT HON. LORD TALBOT DE MALAHIDE.

JOSEPH BEETE JUKES, M.A.

HENRY HEAD, M.D.

March 10, 1852.—"Sketch of the Geology of the County of Waterford;" by J. Beete Jukes, M. A., Director of the Geological Survey of Ireland.

Mr. Jukes exhibited the map and sections of the Government Geological Survey of the county of Waterford, and read a paper to the Society, of which the following is an abstract:—

He premised that he appeared before the Society, not in his individual capacity, or as bringing forward the results of his own personal labours, but as the official representative of the department to which he belonged. The principal part of the work he described had been performed by the assistant geologists, Mr. W. S. Willson, Mr. G. V. Du Noyer, and Mr. Andrew Wyley. His own share of it had been almost entirely confined to the inspection of some of the principal points, and the harmonizing of the general results:—

The rocks that enter into the composition of the county of Waterford belong to the following formations:—

1. The Carboniferous.
2. The Devonian.
3. The Silurian.

He first briefly described the mineral and lithological character which these rocks assume in this district, and that of the igneous rocks associated with them; he then examined their actual and relative positions, and the lines of disturbance and dislocation by which they have been affected, and lastly mentioned some points of interest in the history of their formation. In the first description he commenced at the base of the lowest formation, and worked upwards.

The lowest beds we have in the County of Waterford are certain dark rotten slates, in some places fossiliferous, as at Newtown Head, where they are interstratified with beds of feldspathic ash, and contemporaneous feldspar trap. In the upper part of this band of slates there occur two little, calcareous beds, on the north and west side of the Bay of Tramore. The lowest of these is seen at a place called Quillia. It consists of beds of calcareous grit and sandstone, with a few bands of ash. It is full of organic remains, especially Trilobites, principally *Phacops Jamesii.* The uppermost limestone is seen at intervals for about seven miles, striking N.N.W. and S.S.E. through the town of Tramore. This limestone, in its lithological character, strongly reminded him of the Bala limestone of

North Wales, and its organic remains, though not yet fully examined, were believed to have a great similarity to those of that bed. Over this limestone comes a band of feldspathic trap and ashes, over which is another band of slate, and then a very large mass of trap of various kinds. This great expanse of trap forms an area twenty miles long by four or five in width, stretching from the north and west of Stradbally to the north and east of Waterford. Throughout this tract the rock appears very frequently at the surface in rough knobs and ridges of small hills, but these are so environed by thick masses of coarse drift, that no continuous section can be seen for any large distance. Where it strikes the southern coast, it forms cliffs of a rocky and precipitous character, often not easily accessible, very greatly indented by numerous coves and small bays, and little jutting headlands, and the general course of the coast line is so very oblique to the general strike of the rocks, that even here, where all the rocks are admirably exposed, it is difficult to arrive at any clear results as to their order of superposition and general relations. We get the same phenomena repeated again and again, with every imaginable variety of form and condition, in the perpetually varying cliff surfaces; and the mind thus gets bewildered with an infinity of detail, and unable to disentangle the several individual parts from such a network of confusion.

It can only be said, therefore, that we have in this mass of trap the following varieties of rock, without attempting to describe the exact order of their formation, or the exact mode of their occurrence:—

1. Contemporaneous feldspathic trap, more or less bedded and interstratified with the slates.

2. Feldspathic trappean ash, either hard and compact, or flaky and falling to powder.

3. Trappean breccia and conglomerate in a base of ash.

4. Intrusive feldspar trap, often not to be distinguished from the contemporaneous trap, except by its cutting across the beds; sometimes, however, having a much more crystalline character, and becoming a feldspathic porphyry, or even passing into a rock that can hardly be called anything but syenite, although the hornblende is either absent or rare.

5. Greenstone. This, so far as we know, is always intrusive; it is sometimes in the form of typical greenstone, a dense, dark-green,

compact stone, the crystals invisible to the naked eye, sometimes more coarsely crystalline, and sometimes very largely so, exhibiting a mass of confused crystals of feldspar and hornblende a quarter of an inch in diameter.

The last two rocks were sufficiently well known to all, but of the three first he would say a few words, as they were rocks not to be learnt by hand specimens, and only to be understood, and he might perhaps say believed in, by those who have long worked at them in the field. He might say this conscientiously, and from experience, because when he joined the Geological Survey of Great Britain, in 1846, he certainly doubted and disbelieved in the possibility of old beds of contemporaneous feldspar trap and their associated ashes and breccias being discoverable in these rocks. He spoke, then, now from experience, not gained solely or chiefly in Waterford, but also from some years' work in the mountains of North Wales.

1. Contemporaneous feldspathic trap is usually very fine-grained and compact, and would commonly be called compact feldspar. It has, however, here and there a little shining facet, showing a lurking crystal, and sometimes these crystals become even numerous. In a weathered surface of this trap it is not uncommon to see lines of little knobs and nodules that one at first takes for pebbles, and the whole rock looks at a distance like a coarse sandstone very regularly bedded, and containing thin bands of conglomerate. None of these nodules can be traced in the interior of the rock, but there is sometimes to be seen in it a set of coloured lines or bands, which are due entirely to what the Germans call "streckung," or stretching. We must suppose that the viscid, half-fluid mass, as it flowed along on being erupted, acquired a grain, as it were, or a regularly streaked character, from its own motion, as you might see in a mass of dough pulled out. Some of these bands became harder than others, and a first attempt at a nodular or concretionary form took place, not sufficient to be perceptible in the mass of the rock, but enough to show itself as the result of long-continued weathering.

2. Trappean ash. During some part of the eruption of the feldspathic trap, whether it were above or below water, we must almost necessarily suppose ashes and papillæ to have been ejected, and, falling in the water, to have formed beds of rock. If these were very fine-grained, and fell unmixed, they might form a hard compact stone, which a subsequent slight degree of temperature would so

bake that it should hardly be distinguishable from the trap itself, and when highly altered it must necessarily be absolutely indistinguishable. Sometimes, however, it was of coarser materials, and the stone is now composed of grains and flakes, and small angular or slightly rounded fragments of feldspar. It frequently contains, also, so much calcareous matter as to effervesce with acids, and sometimes it has in it the casts of shells and other organic remains.

3. Brecciated ash or ash conglomerate. In the year 1850 he met in North Wales with a very puzzling rock, and it appears that at the same time Mr. Willson came on the same at Waterford, at Newtown Head. It had a base of compact feldspar of a greenish-grey colour, with many large crystals of opaque white feldspar dispersed through it. He at first set it down as a porphyry, but in tracing it found the crystals of feldspar sometimes get as large as one inch or one and a half inches in diameter, that they were discoloured at their surfaces, and, although not perceptibly rounded, yet they were easily broken out and detached from the matrix. He afterwards, in tracing this rock, found it to contain angular fragments of feldspar trap, and eventually fragments of slate, and these sometimes in great abundance, angular fragments of slate and trap, several inches across, being mingled with smaller ones, more or less rounded, so that the whole became a coarse breccia. He then perceived that the small dispersed crystals of feldspar he had met with at first were not produced where they are now found, but were crystals that had either been washed from other rocks, or had been blown out of the orifice of the volcanic focus in the neighbourhood, together with the ash, and become imbedded in it on falling together into the water.

Now in Waterford there are abundance of these three kinds of rocks, more or less interstratified with small bands of slate and some larger ones, the whole pierced and traversed in every direction by great masses of subsequent and intrusive feldspar trap, and by equally large masses and numerous dykes of greenstone in all its varieties.

Above the principal mass of trap thus constituted, there is another large mass of black, blue, and grey slate, very sparingly fossiliferous, and in this are found occasional small interrupted beds of trappean ash, and small intrusive masses of greenstone.

The total thickness of Silurian rocks seen cannot be less, and may be more, than 8000 feet, inclusive of the traps, and 5000 feet

exclusive of them. They must be taken to belong wholly to the lower Silurian, nothing having been seen that either lithologically, or from its organic remains, could be at all considered likely to belong to the upper Silurian beds.

DEVONIAN FORMATION.—The lowest beds of the Devonian or old red sandstone formation consist of dull red sandstones and conglomerates. These conglomerates, when they form the actual base of the old red sandstone, are almost entirely composed of pebbles, and more or less angular fragments of those Silurian rocks on which they immediately rest. Higher in the formation the pebbles are principally quartz. Beds of red marl and of fine-grained red sandstone alternate with the coarser sandstones and conglomerates, and as we ascend in the series the fine-grained begin to preponderate over the coarser matters. Beds of yellowish or pale-grey sandstone likewise alternate with the red beds. These are often very hard and brittle. Ascending still higher, it usually happens that the red colour begins to disappear, or only occurs occasionally, and we then have beds of pale yellow or whitish sandstone as the *most prominent* feature of the upper part of the formation. This is the yellow sandstone of Mr. Griffith. On the north side of the county, between Waterford and Clonmel, this is a very persistent and uniform group of rocks. The thick-bedded, yellowish sandstones are very prominent, but between them, when a good section is found, are seen beds of shale, either red, green, yellow, or grey, and sometimes even a dark-grey. A greenish-yellow, very fine-grained flagstone is of very common occurrence in these beds. In the southern parts of the county, namely, on each side of Dungarvan Harbour, and down towards Ardmore, these upper yellow sandstones have these same characters. But as we trace them towards the west, namely, from Dungarvan towards Lismore, or from Ardmore to Youghal, we find the sandstones to diminish both in thickness and number, and the intervening shales to increase, especially in the upper part of the group, so that we finally have towards the west a set of beds on this horizon to which the term "yellow sandstone" becomes inapplicable, in a lithological sense, because they consist principally of a dark blue or grey shale, or, as it is almost always more or less affected by cleavage, a dark slate. This dark slate above the red beds of the old red sandstone, which is Mr. Griffith's carboniferous slate, is often scarcely distinguishable by any lithological character from the Si-

lurian slates below the old red. As, therefore, the terms "yellow sandstone" and carboniferous slate are thus likely to lead us into error, if generally applied, we should prefer to look on them as local terms only, applying accurately to certain localities, but generally it would be best to speak of the beds in the south of Ireland which intervene between the carboniferous and Silurian formation, as "Devonian," and to subdivide them into upper and lower Devonian. The upper Devonian would then include Mr. Griffith's yellow sandstone and carboniferous slate, which Mr. Jukes looked upon as contemporaneous beds, differing only in the materials of which they are composed, and the lower Devonian would be equivalent to the true old red sandstone.

The organic remains of these Devonian rocks are confined entirely to the upper division. They consist in the yellow sandstone of fragments of plants, in the carboniferous slate of marine shells. He believed from evidence, not gained in the district then under consideration, that we have in these two rocks a contemporary marine and fresh-water formation; that while the mud of the carboniferous slates was being deposited in a deep open sea on the S.W., and including thus marine remains, the sands of the yellow sandstone were being formed in the shallower waters of the N.E., along an ancient coast into which rivers and brooks emptied themselves, and brought down and deposited the remains of the land and of fresh water.

The thickness of the Devonian system in the south of Ireland will thus vary according to the circumstances of its original deposition. In Waterford he should state

The Upper Devonian as 700 feet.
The Lower do. 3000 ,, or upwards.

THE CARBONIFEROUS.—In the county of Waterford we have only portions of the base of the carboniferous system, namely, the mountain limestone, and those portions only the bottom beds of that subdivision, namely, the lower mountain limestone. This, in Waterford, as generally in the south of Ireland, consists of thick-bedded, light grey limestone, sometimes compact, sometimes crystalline, usually a more or less pure carbonate of lime, but sometimes containing a great quantity of magnesia, and becoming a true dolomite. At the base of the thick-bedded limestone, there is sometimes, *but not always*, a set of shaly beds, black shales alternating with thin

bedded flaggy limestone. These often pass down by such insensible gradations into the dark shales of the upper Devonian rocks that any line between them becomes a purely arbitrary one, and he believed that we often have a true passage or transition by insensible degrees from one formation into the other. Practically the best way is to take the lowest bed of limestone at any locality as the boundary of the carboniferous system, and to consider all below that as Devonian. In this way it is much more easy to draw a line between the carboniferous and Devonian systems, than it is to draw one between the upper and lower Devonian groups. The latter, indeed, sometimes becomes, *ex necessitate rei*, a purely hypothetical division, for the sandstones and shales, which in general are yellow or grey or blue, become in places all red, and the whole Devonian formation, in consequence, one homogeneous mass.

THE RELATIVE AND ACTUAL POSITION OF THE ROCKS.—The appearance of the Silurian rocks at the surface is confined to the eastern half of the county of Waterford. They form a gently undulating, rather barren and rocky, but not a lofty tract, extending over nearly the whole of that part of the country. The strike of their beds is generally E.N.E. and W.S.W., the dip on the whole being to the W.N.W., at no very considerable rapidity of inclination. The beds, however, are greatly contorted, and roll and undulate in all imaginable directions, at all kinds of angles, so that single or isolated observations are of no value whatever, and the general position of the rocks is only discoverable after the whole country is examined. The calcareous bands of Tramore, after being perceived at intervals for six or seven miles, dipping N.W. under the traps, do not again reappear in that direction. The broad band of the principal mass of trap, after disappearing under the slates to the N.W., likewise remains concealed underground, and does not re-appear, though the Silurian district stretches twelve miles further in that direction.

Upon the upturned edges of the Silurian rocks, and equally on the highest and the lowest of these rocks, rest the beds of the Devonian formation. On the western side of the undulating and contorted Silurian district stretches the bold range of the Comeragh mountains. These in their central part rise 2600 feet above the sea, consisting of at least 1500 feet of old red sandstone in nearly horizontal beds reposing on the Silurian rocks. They are broad, flat-topped hills, with wide swelling heathery moorlands that end

suddenly towards the east in grand precipices, with jutting capes and headlands, exposing sometimes nearly their whole thickness of old red sandstone in vertical cliffs, with merely a talus of fallen fragments at the foot. From this lofty central mass, the beds decline on either hand, both towards the north and south, at first very gradually, but at last, with a sudden dive, they plunge beneath the valley of Dungarvan and Lismore on the south, and beneath that of Clonmel and the Suir on the north. On this north side the beds strike east, with a mean dip of 30° to the north, as far as Waterford, just north-east of which they flatten and sweep round towards the north and south, on the one hand sweeping with the most symmetrical curve round the east end of the valley of the Suir, and running back to the west, along the north side of it, everywhere plunging under the flats of the mountain limestone; on the other, running in a broken and interrupted line down the sides of Waterford Harbour, and disappearing in the sea, south of Dunmore. That they continue under water a little south of the coast stretching from Waterford Harbour to Dungarvan is highly probable, and is made still more so by the fact of some small masses of old red sandstone being let in by complicated faults into the Silurian rocks of the coast near Bunmahon, where they may be seen in the cliffs, and are found in the mining operations at Knockmahon. The Silurian district, therefore is enclosed in a ring of old red sandstone, broken on the east, and concealed on the south by the waters of the sea.

On the west of the Comeragh mountains the old red sandstone stretches out in a broad, lofty, and barren district, and its beds are very shortly tilted up at steeper angles, and form the lofty peaks of the Knockmealdown Hills, some of which rise likewise to a height of 2600 feet above the sea. The outline of these hills is singularly different from that of the Comeraghs, considering that they rise to the same altitude, and are composed of the same beds. The Knockmealdowns are a narrow mountain ridge, with sharp conical peaks and a serrated outline, almost resembling a volcanic range; the Comeraghs are a great solid mass of land that would have been a great gently undulating plain, had not all the surrounding rocks been worn away, and this gnawed and indented lump alone left standing, like a pillar in an incomplete railway cutting, to show the amount of excavation around it.

The beds of the Comeraghs form one low arch of very gentle cur-

vature, except just at each abutment; those of the Knockmealdowns are frequently and rapidly undulated in very sharp curves. This undulation continues both north and south of them, as seen in Section 2;* and as the general level of the rocks declines on either hand, we get rolled in, first, patches of the upper Devonian or yellow sandstone, and then pieces of still higher rocks, namely, the mountain limestone. These undulations are in the form of long ridges and furrows, or synclinal and anticlinal curves, the axes of which run east and west, forming a succession of fertile valleys and bare broad ranges of high land over all the western half of the county of Waterford. There are four principal synclinal hollows, namely, that of Lismore stretching from Dungarvan to Fermoy, that of Tallow, that of Clashmore, and that of Ardmore. In each of these is a considerable thickness of mountain limestone; and generally we find that wherever the beds of the lower rocks plunge downwards at a sufficient angle and for a sufficient distance, a portion of the mountain limestone is brought in above them. We can, therefore, hardly fail to be convinced that the mountain limestone formerly stretched over the whole district, and has since been removed by denudation from all the loftier ground, those parts only being preserved that were enabled to nestle comfortably down into the hollows of the other rocks.

As regards the structure of the country he had only further to say, that several faults of very considerable magnitude had been discovered, and some of them apparently of great extent. These faults run north and south across the axes which mark the principal direction of the elevatory force The most remarkable are some near Ardmore and Whiting Bay. The latter half is bounded on each side by a fault, the downthrow of which is towards the Bay, the united action of these faults having been the very cause of the existence of the Bay.

The limestone of the two valleys of Clashmore and Tallow is cut off towards the east by a fault, which is an upcast towards the east of several hundred, perhaps a thousand, feet; and this fault is even traceable across the Lismore valley two or three miles to the east of Cappoquin. Parallel to it is another north and south fault, like-

* These sections will ultimately be published in the Section Sheets of the Geological Survey.

wise an upcast to the east or down to the west, that runs just west of Cappoquin, right down the valley of the Blackwater for some miles towards Youghal. Although the amount of its throw is not very great,—not so great as the faults on each side of it,—being not more than 520 feet, it is still highly probable that to this fault is due that very remarkable and sudden deviation of the Blackwater river, which at Cappoquin causes it to leave the valley it had hitherto traversed, and, instead of running out to the sea at Dungarvan, to run in a narrow ravine cutting right through all the ridges due south to Youghal.

He then briefly called attention to a few points in the history of the formation of these rocks, and of what has happened to them subsequently.

First, the volcanic agency had its most intense period of action about the middle of the time during which the Silurian rocks of this district were formed, but it did not entirely cease till long after that, as not only do we find here and there igneous rocks in the uppermost Silurian beds of this country, but on the coast near Bunmahon beds of the old red sandstone period have been altered and cut through by greenstone, and trap rocks show themselves cutting through the old red sandstone near Aughaviellia bridge, a few miles south-east of Clonmel, and near Ballynamult, half way between Clonmel and Dungarvan.

After the Waterford Silurians had been all formed, and before a single inch of the old red sandstone had been deposited on them, forces of disturbance had powerfully affected them, bending, contorting, and tilting them up, and bringing them within the reach of forces of denudation. These forces of denudation had so acted on them as to have worn and ground down the surface of the Silurian rocks to very nearly its present condition. They had, at all events, removed several thousand feet of strata, since we now find the beds of the old red sandstone reposing indifferently on the edges of the uppermost and lowest of the Silurian beds of Waterford, and we have already seen that the lowest must have once been covered by at least 8000 feet of slates and traps. We can hardly conceive of any other force of denuding agency than the action of the breakers at the surface of the sea, the wearing action of tides and currents for a comparatively short distance below the surface, and the very slow and trifling action of rain and wind, and the other atmospheric agents on rocks

when above the level of the water. To allow these agents to have produced this enormous amount of action we must suppose the Silurian rocks to have emerged very slowly into dry land, suffering to this extent in the operation. At the commencement of the old red sandstone period the Silurian rocks were certainly subject to the action of the breakers, forming banks of shingle and pebbles, which are now the old red sandstone conglomerates. It is probable that this took place during a period of depression, and that as the sea gained upon the land, each previous beach being now in deeper water, became covered with sand and protected, while the next was forming, and so on. From this it would follow, that where the highest bits of old Silurian land were in the old red period, those which were the last to disappear beneath the old red sea, that formation would have the least thickness; from this cause, if from no other, those spots would be the first to re-appear at any subsequent period, and are probably those where we now have Silurian rocks at the surface.

Round the borders of these districts, therefore, we may reasonably conclude the old red sandstone to be thinner than elsewhere, or in other words, we may suppose it to thicken as we recede from them.

When the Silurian rocks had become fairly plastered over with old red sandstone, the depression still continued, until, as we have already seen reason to conclude, the mountain limestone was spread out above it over the whole district. We have already seen that our lines of separation in the Devonian and carboniferous rocks are purely arbitrary, that there is every evidence of a gradual and successive accumulation of materials, without interruption or disturbance, from the bottom of the old red sandstone fairly up into the middle of the mountain limestone. Now we know that in the rest of Ireland and in Great Britain there is no appearance of any break or change having occurred from the bottom of the mountain limestone up to the very top of the coal measures. However startling it may appear at first sight, therefore, we ought to hold ourselves prepared to believe in the possibility of the whole of the coal measures having once extended in level sheets over the county of Waterford. Now the coal measures of South Wales are 12,000 feet thick, the mountain limestone of Tipperary and Kilkenny is 3000 feet thick, and we have already seen that the Devonian rocks of

Waterford are nearly 4000 feet thick. There is, therefore, a geological *possibility*, he did not say a probability, but a fair geological possibility of the Silurian rocks of Waterford having once been covered by 19,000 feet of other rocks, and of their having been depressed therefore at least that much below the level of the sea. If we halve that amount, and say 8000 or 10,000 feet, the possibility rises into a *probability*, because it is an absolute certainty that they have been depressed 4000 or 5000 feet, and that amount of strata at least accumulated upon them. This depression took place in such a way during the whole Devonian period, that it was probably greater on the S.W. than on the N.E., in which quarter there was still dry land, on which grew large ferns and other plants, with lakes or rivers of fresh water, and fresh water shells. It was continued, however, till even this land, if it still existed, became more remote, and the clear seas in which mountain limestone was deposited flowed over the whole country. Gradually these seas became shallower again, either by elevation or by filling up, sand and mud again prevailed in them, and coal was formed either below some shallow water, or, as is now more generally believed, a little above its surface. On the latter supposition we must suppose that the seas were filled up by the accumulation of materials while the depression still continued to operate, and thus the successive beds of coal became gradually buried one after the other.

At some subsequent period another elevation took place, and consequently another great denudation. This may have been a single and continuous operation, or it may have been distributed over the whole lapse of time from the close of the coal measure period down to our own days. That a large part of the denudation, however, is of early date is rendered probable, if we look across the Channel, and compare the geological structure of the south of Ireland with that of South Wales and the south-west of England, for it would appear highly probable that as the formation of the rocks was contemporaneous in each place, so were the parallel lines of disturbance (both running east and west) likewise contemporaneous. In Britain we know these disturbances and the consequent denudations were brought almost wholly to a close before the deposition of the higher beds of the new red sandstone. We may therefore assume the same period for those that have affected the south of Ireland.

He must, however, utter a warning against M. E. De Beaumont's theory of the cotemporaneity of parallel lines of elevation being carried too far. In the British Isles alone we have three cases of east and west strike which have been communicated to rocks at three widely different epochs. In North Wales the whole of Denbighshire is occupied by Silurian rocks that strike east and west, traversed by a multitude of east and west anticlinal and synclinal lines, every one of which was produced before the Devonian period, since the old red sandstone and mountain limestone lie flat across the edges of the beds, and strike north and south. In South Wales and west of England, and, if we rightly believe, in the south of Ireland, the east and west strike was communicated to the rocks after the close of the coal measure period, and before that of the upper part of the new red, probably, therefore, during Murchison's Permian period. In the south of England again, in Isle of Wight, and in the Weald of Kent, the east and west strike was given to the rocks there after the formation of the chalk or during some tertiary period.

April 14, 1852.—"Remarks upon the Geology of the Vicinity of Ballyshannon;" by ROBERT CRAWFORD, Esq.

THE principal rocks occurring in this neighbourhood are carboniferous limestone, sandstone, and mica schist, passing into gneiss.

Among these, the limestone occupies the most conspicuous place, being of greater extent than the two latter formations taken together. It is generally of a dark blue colour, fine in texture, extremely hard, and in most places highly crystalline. It is much used here as a building stone, and is very durable.

At Bundoran, about three miles to the south-west of Ballyshannon, the limestone appears along the banks and on the shore in shelving rocks jutting into the sea. These abound in fossil shells, &c., so that in some places they seem entirely composed of them. Here also, numerous white veins of calcareous spar appear traversing the rock in the direction of the dip. To the north-west of Ballyshannon, on the shore near the Old Abbey, a vein of zinc blende occurs, but as it is now covered with large loose stones, my time

was too limited to examine it minutely. This neighbourhood is also extremely rich in fossils.

The next rock in order of extension is sandstone. It is of a yellowish grey colour, even texture, and in some places where it is exposed it is very hard, so as to strike fire with steel. This formation occurs in two distinct places, at Bundrowes, on the border of the County Leitrim, and again at Kildoney Point, to the north of the entrance to Ballyshannon Harbour. In both places the stone is perfectly similar in appearance. Notwithstanding a very close examination of this for some days, I was unable to find any *fossils*, or even the *traces* of any organic remains in it, except a few imperfect impressions of plants.

In one place I found it overlying the limestone, both having the same dip, and apparently conformable. Nor was there any great appearance of disturbance, such as could have thrown them into the position here described (were it not their natural one).

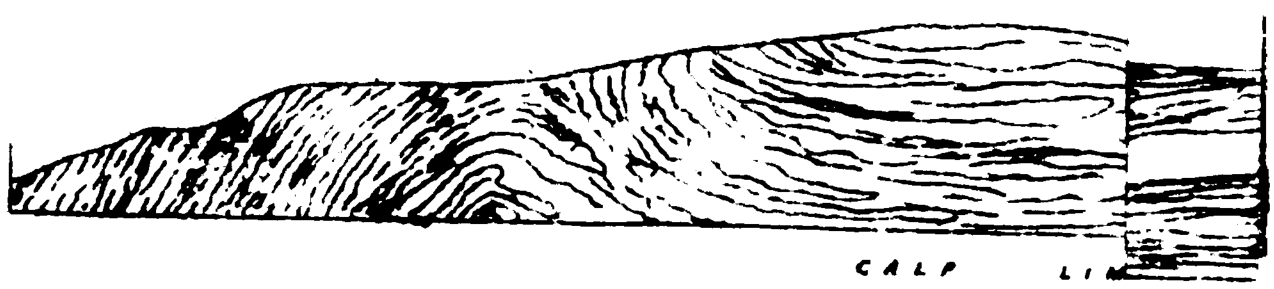
Besides, the dip of the sandstone at this particular spot corresponds very nearly with its general direction in all the surrounding district. From this I would infer that the position held by these rocks in this instance is their true relative position with regard to age, and that the sandstone is the newer formation of the two.

Again, at Bundoran the limestone has a general tendency to dip towards the south-west, while the sandstone to the south of this point, *at a much higher level*, dips in pretty much the same direction. This, I think, strengthens the opinion I have already given with regard to the relative ages of these two rocks.

At a quarry at side of road leading from Bundoran to Kinlough, the sandstone alternates with a greenish rock, rather slaty.

At the town of Ballyshannon, and in something like the shape of the letter V (the point being next to the sea), mica passing into gneiss occurs. It is very hard and massive, and not nearly so fissile as mica schist. The dip is uncommonly well marked in many places, and the junction of this rock with limestone on both sides is visible. This rock goes by the name of *whinstone* among the labourers, on account of its toughness.*

* Vide Section 2, Pl. 2.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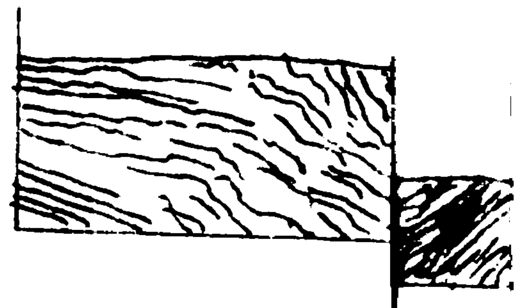


3


TRAP

May 12, 1852.

Mr. Hamilton exhibited a section of the cutting on the Drogheda and Navan Railway, south of the Beauparc station. The object of it was to illustrate the contortions of the calp limestone, which is here finely bedded, among which there are two beds, 5′ and 1.5′ thick, of crystalline limestone. He remarked that there was evidence of two kinds of disturbance, one of an upward force, which has heaved up both the calp and crystalline beds: the other, a horizontal force, which has twisted the calp, the direction of which was about in *the line of section.*

These contortions are visible along a line perpendicular to the line of section for some distance.*

June 9, 1852.—"Notes on the Geology of the Country about Kingscourt;" by John Hamilton, Esq.

The part of the country described by Mr. Hamilton, and of which a map and section were shown at the meeting,† is a district which has for its central point the junction of the Counties Meath, Cavan, and Monaghan. The general features are:—The calp, or dark shaly limestone, covered with gravel hills, particularly towards its northern extremity; it is bordered on the N.E. and S.W. by the mountain limestone, which rises into rugged rocky hills; from these hills the coal measures and new red sandstone fall to the base of the high hills of Silurian slate which bounds the district to the west.

Beginning with the calp or black limestone, which occupies an extensive tract, its general dip is, I think, to the N.W., but as it is everywhere very much contorted in places where I observed the dip, it read N. and E. of N., and even E. of S. It is everywhere intersected with veins of chert.

Associated with the calp is another formation, which assumes very different appearances in the two places where I observed it. In the first of these it is a sandy shale exposed in a glen through the

* Vide Section 3, Pl. 3. † Vide Section 4, Pl. 4.

calp; it seems to lie conformably to the latter, though at a higher angle, both it and the calp, at the nearest point of observation, dipping to N. 25° W. In the second place, it is a fine-grained, finely stratified sandstone, which varies very much in hardness, sometimes becoming a friable white mass. This is visible in mass only in one place, where it dips W. 9° N., at an angle of 35°, but traces of it are visible near its limits, where it seems to have joined the calp, and in these places it is *distinctly interstratified with the calp.* It is intersected with veins of chert exactly like the calp, and seems, when in a soft state, to have shared with it the influences which have contorted it as the calp is. It seems that at one time it had a much greater extent, and that it has been worn away by denudation, both from the surface it presents, and also from the fact that the gravel hills are full of fragments of the same kind of sandstone and bits of chert, mixed with pieces of calp and mountain limestone. This formation, then, belongs to the grit beds of the carboniferous limestone, and in this instance is associated with the calp division of that system. In tracing the black limestone up a glen in the bed of the stream, and in ground on each side, there are several nodules of various sizes which have been worn by the stream out of the calp. As I could not find more than one *in situ*, I cannot say whether they are distributed in layers in the calp; but some are found of an appearance as if once joined together, like grape-shot. The constituents of these nodules are the carbonates of lime, magnesia, and iron, in the following per-centage: 68.64 per cent. of carbonate of lime; 2.64 per cent. of carbonate of magnesia; and 5.60 per cent. of carbonate of iron; the remainder being made up of silex and iron pyrites, which fills the columnar divisions of the stones.

100 grains gave—

Insoluble Matter.

Silex and Iron Pyrites ($Fe\,S_2$) + loss,	23.12
$Fe\,O, C\,O_2$,	5.60
$Ca\,O, C\,O_2$,	68.64
$Mg\,O, C\,O_2$,	2.64
	100.00

At this point the valley is crossed by a ridge of a fine-grained crystalline greenstone; the mass is about ten feet thick at the surface, and is visible for 30 yards, running W. 30° N. This intru-

sion changes the dip of the calp at the spot, causing it to form a synclinal. Further up the valley there is another mass of the same, running W. 34° N. The next formation is the mountain limestone, which forms rugged hills, covered with large masses of the stone, which have been greatly water-worn. Its general dip is a few degrees *south of west*, and at an angle of from 10° to 20°, with *very distinctly marked joint planes*, which run N. 25° E. throughout the whole mass. It is in many places highly fossiliferous,* but in one part it becomes destitute of fossils, and hard and highly crystalline, almost a marble, though I cannot account for its being so highly crystalline in this point. In the middle of the limestone (near Breslaustown) one of the forms which it takes is in a thick bed which is a brecciated mass, and appears as if formed of angular pieces of limestone, cemented together by the pouring in of large quantities of sandy carbonate of lime.

The mountain limestone is succeeded on the east by a gritty sandstone. The change is a gradual one, the limestone gradually becoming more sandy till it becomes a perfect sandstone. This is another form of the grit beds of the carboniferous limestone, in this case associated with the crystalline beds of it.

Overlying the mountain limestone comes the coal measures, which in many places rise up, forming a cliff to the S.E., where I observed it and the limestone close together. They were conformable, though at a distance it is not so. They dip at an angle of 26°, and have very distinct joint planes running in the same direction as those in the limestone. It varies in character very much, from a compact red and white freestone to a loose, sharp, siliceous sand. In many places it contains impressions of stalks, and thin beds of coal and coaly matter. The place where I observed the latter more particularly is in a cutting of a stream, forty feet deep, to drain a lake. Between the limestone and the sandstone there were:—1st, stiff clays; 2nd, thin seams of coal and coaly matter; 3rd, friable variegated shale; and this order was repeated over and over again. At one point there are, interstratified with the coal sandstone, three beds; the upper one of these is a bed two feet thick, of an impure calcareous sandstone, the middle one a bed one foot thick, of a black

* Containing the genera Euomphalus, Bellerophon, Spirifer, Loxonema, Cypricardium, Productus.

fissile shale; and the lowest a bed five feet thick, the same as the upper one. The middle bed is full of impressions of shells, and some traces of plants, which seem to have all suffered great compression, being greatly flattened out. The shells belong to two genera, Goniatites and Pecten. The trough formed by the slate hills and the inclined sandstone beds is filled with red and blue loams and marls, and stiff plastic clay of the new red sandstone formation; in the centre these are horizontal; but at the edges it seems to dip, so as to take the form of the trough in which it lies. In one place, as far as I observed, there are several beds of gypsum, separated by thin beds of plastic clay. By boring they have ascertained that these beds are forty feet thick, at least; but no traces of salt beds are found either from boring, or in the springs of the district.

The high hills to the east stretching northwards are formed of green Silurian slates standing at a very high angle. They separate into very thin laminæ, the divisions being made in the planes of stratification, and not in those of cleavage; the divisions in the direction of cleavage are filled up and cemented together again by seams of carbonate of lime. They dip on one side of the hills to the S. 26° E., and over the hills to N. 35° W., appearing to form a very high anticlinal axis. At the base of these hills there is generally a talus of coarse gravel, formed of water-worn pieces of the Silurian.

ANNUAL ADDRESS

OF

THE PRESIDENT,

LIEUT.-COLONEL PORTLOCK, R.E.

DELIVERED FEB. 11TH, 1852.

GENTLEMEN,—In addressing you on this occasion I shall adhere to the system which I adopted in my Address of last year, and divide the subject of our researches and studies into the two branches of Physical and Organic Geology.

In the first of these branches it may appear to many that we are restricted to the examination of our own planet, and that it would be vain to look beyond the limits of the earth itself for any information calculated to throw light either on its structure or on the phenomena exhibited in the various dislocations and disturbances of its surface; but though it would undoubtedly be unwise to base our science on observations drawn from the external planetary bodies, or to resume those cosmical dreams which led the early cultivators of natural science into the field of dazzling but useless speculation, it is assuredly only right to ascertain whether the conclusions we have drawn from terrestrial observations alone are in conformity with the laws which regulate the combinations and the condition of matter throughout the universe. If, indeed, we investigate laws rather than isolated facts, we perceive that there is every reason to believe that they are general and not local; that they are not limited to the earth itself, or local, but are in equal operation throughout the visible universe. And it is thus, for example, that with each fresh discovery of a new planet, there is obtained additional proof of the universality of the great law of gravitation. Keeping, then, in view the great probability, at least, of uniformity in the laws of nature, we

are justified in applying the knowledge acquired of other planetary bodies to the rectification of anything which is imperfect in that of our own. In studying the earth with a view to the elucidation of the phenomena exhibited by its surface, it has, for example, been found necessary, or at least it has been thought necessary, to assume that the planet was once in a liquid state, that the cause of its fluidity was original heat, and that a portion of the crust has cooled down, and become solid, in proportion as this heat has been radiated into space. According, therefore, to this hypothesis, it is supposed, that some portion of the earth is still in a liquid state, either as a central nucleus, if the consolidation has commenced from the surface; or an intermediate annulus, if the consolidation has proceeded simultaneously from the centre and surface. This hypothesis has been principally maintained on two leading arguments; namely, the evidence of internal heat, and the coincidence of the form of the earth with that which would be assumed by a fluid body rotating upon its axis, in the manner of the earth.

Before, however, I enter on the latter consideration, let me notice an independent objection which has been urged against the theory of a still existing liquid nucleus by that eminent philosopher, Mr. Hopkins, now President of the Geological Society of London, namely, that under the very great superincumbent pressure of the superficial mass a condition of liquidity is impossible. To maintain this objection it seems to me necessary to establish what are the actual conditions of fluidity. One of these is manifestly a temperature, definite as regards each substance under some one fixed pressure, and another a definite pressure, estimated as regards some fixed temperature. But there is another condition which must materially affect the change from a liquid to a solid, or from a solid to a liquid state, namely, the mode in which the particles of the body are arranged when they assume a crystalline form.

Let me, for example, inquire how these conditions may be supposed to affect the great mass of water which forms an envelope to so large a portion of the earth. Water, then, is known to us in three different states: as vapour in steam; as a liquid in water; and as a solid in ice. The change from the liquid to the gaseous or vapourous state can be examined in reference to the conditions both of temperature and pressure, and it is found that as the pressure increases the temperature must also increase, in order to effect the desired

change, or to transform the liquid water into the gaseous steam, and it is therefore possible to conceive that a pressure might exist more than equivalent to the effects of any conceivable increase of temperature. But what is the state of the case, if we examine the other change, namely, that of the liquid water into the solid ice. If this change take place by abstraction of caloric or by congelation, M. Person has shown that there is an intermediate state in which water resembles a viscous rather than a fluid or solid mass. It is in this state that water, contrary to the usual effect of increasing cold, begins to expand by a re-adjustment of its molecules, until at length it becomes a crystalline solid in ice, which occupies more space than the fluid water, and is therefore specifically lighter. What, then, should be the effect of an alteration of pressure on this remarkable change? It might be supposed that a diminution of pressure ought, so far as regards the expansion or crystallization, to facilitate freezing, or to raise the freezing-point, and an increase of pressure ought to restrain it; but though the latter must be the case, there does not appear any means to establish a balance, as diminished temperature would only lessen the power of the body to assume a more bulky form, or to resist the compression of pressure. Nor, indeed, can even the first proposition be admitted, as expansion from temperature may take place without the assumption of a crystalline condition.

Is it, then, possible that water may be solid and not crystallized? So far as our knowledge at present extends, I am not aware that this question can be otherwise answered than by a negative. The sounding-line has penetrated depths of an ocean amounting to about two miles, or 3500 yards, and though the temperature has been found little above the freezing-point, a state of perfect fluidity has been preserved, though under a pressure of more than 100 atmospheres, and there is little reason to doubt that the result would be the same at the probable extreme depth of our ocean, or under a pressure of 200 atmospheres. We see, then, that the change from the liquid to the solid state depends in water on peculiar molecular properties or relations, which are in some degree consequent on a particular state of the body as regards caloric. In other substances the effects of the changes from a liquid to a solid, or from a solid to a liquid state, may be less striking; but I am not aware that any experimental evidence can be adduced to show that when a body has

assumed a liquid state, to which certain molecular arrangements are essential, that it can, by pressure alone, or without the loss of caloric, be restored to the solid form.

At the present time Mr. Hopkins is engaged in a series of experiments, at the instance of the Royal Society, on this most important and interesting subject; and, aided by the great mechanical ability of Mr. Fairbairn, there is little doubt that he will ere long arrive at a determination of the limit, if such there be, in masses of mineral matter, where the repulsive force, either exercised by, or called into action by, caloric shall be infinite as compared to the compressing force of pressure, and where fluidity must therefore be permanent, so long as the temperature remains unchanged.

Having thus briefly stated the doubts I at present entertain as to the possibility of reducing to a solid state, by pressure alone, the molten mineral matter of our earth, so long as a sufficiently high temperature can be maintained to insure an adequate repulsive force, I shall proceed to the other objection which has been urged by our able Secretary,—namely, that *all* the planets do not exhibit forms which a fluid rotating upon its axis ought to assume. It would be out of place to repeat here the mathematical reasonings on which Mr. Haughton rests his objections, as they have formed the subject of a detailed paper read before the Royal Irish Academy; but the general character and results of that reasoning I shall now briefly state.

Mr. Haughton, starting from the celebrated theorem of Clairaut, which expresses the results of the combined actions of gravity as an attractive, and of centrifugal force as a repellant force, in a body rotating on an axis, first inquires whether the figures of the several planetary bodies, of which tolerably accurate measurements have been made, fulfil the necessary conditions of that theorem on the hydrostatic or fluid theory. Stating the maximum and minimum limits of the compression which fluid bodies of the magnitudes of the planets should exhibit, Mr. Haughton finds that the compression or ellipticity of Uranus, of Saturn, of Jupiter, and of the Earth, is consistent with the theory of original fluidity, but as regards Mars, that the result is widely different. For example, whilst the major theoretical limit of ellipticity is $\frac{1}{136}$, and the minor limit of ellipticity is $\frac{1}{641}$, the measurements by Herschel (1784) give the polar diameter, 1272, and the equatorial, 1355, or an ellipticity of no less than $\frac{1}{16.33}$.

Hence, if it be assumed that in all cases the liquid mass of the planets had arrived at a state of equilibrium before consolidation, or that, being still fluid, it is in a state of equilibrium, this ellipticity must be considered inconsistent with the conditions of the theorem, and hence a fluid theory will be inadmissible.

Before, however, I further examine this portion of the argument, or discuss the data on which it depends, let me look at the other form of the proposition—namely, original solidity. Reasoning, then, from these two postulates, which are considered observed facts,—namely, first, that gravity is perpendicular to the surface of the earth; and second, that the figure of the earth is that of an ellipsoid of revolution of small ellipticity,—Mr. Haughton shows that the conditions of the theorem of Clairaut are fulfilled by the earth, on the hypothesis of original solidity, and further, that the deduction may be generalized so as to embrace the other planets, including Mars. "It thus appears," he says, "that the theorem of Clairaut, which establishes a connexion between the law of variation of gravity and the figure of the earth, is independent of the fluid hypothesis, and even of any very definite hypothesis, as to the arrangement of matter in the interior of the earth."

So far, indeed, Mr. Haughton appears to avoid, or at least imagines he has avoided, hypothesis; but the difficulty, if not impossibility, of so doing is made manifest by the next passage, where he says:—"The distribution of the materials composing the planets must be such as to satisfy" an equation in which "the difference between the moments of inertia of the earth round the polar and equatorial axes enters as a function of its figure and rotation." It appears to me that this is as great a difficulty in a philosophical solution of the question as can well be conceived, for whilst on the fluid theory the result of rotation of a spherical body is, that it shall assume a compressed figure, and that the force of gravity shall continue perpendicular to the surface, and the figures of all the planets measured with sufficient precision, excepting one, conform to that theory, both in rotation and figure—it is necessary to assume, on the theory of solidity, such an arrangement of the materials as will produce this perpendicular action of gravity; and in the case of Mars, to modify this assumption by another perfectly arbitrary,—namely, "to suppose that Mars contained originally more or denser matter in his equator than the other planets," a supposition which seems to be

at variance with the harmony of nature, and to rest on no reasonable ground. But may we not also ask whether this latter supposition is consistent with the first postulate,—that gravity is perpendicular to the surface? and further, though the mean or average result on the earth may be assumed as a perpendicular direction of the force of gravity to the surface, are there not sufficient local deviations and disturbances to show us that the generality can only be due to equally general regularity of distribution in the matter of the earth? Admiring, therefore, as I do, the mathematical powers of our learned Secretary, I cannot admit that he has as yet satisfactorily solved this great cosmical question; and I shall for a moment turn again to the consideration of the fluid theory.

Mr. Haughton adopts the measurements of Herschel in respect to Mars; but, as pointed out by Mr. Hennessy of Cork, another distinguished mathematician of our College, these measurements have not been adopted by modern astronomers. Laplace* adopts Arago's measurements, the two diameters being in the proportion of 189 to 194, and Schubert† gives the measurements of Schröter, which afford a ratio of 81 to 80, though he also quotes those of Herschel. It thus appears that the following proportions between the polar and equatorial axes have been given by independent observers, namely:

1.0667,	or ellipticity,	$\frac{1}{16}$
1.0265,	"	$\frac{1}{38}$
1.0125,	"	$\frac{1}{81}$

which exhibit a very remarkable discrepancy, and although the results are all in excess of the theoretic compression, I cannot admit that, in consequence, it must be assumed that the fluid theory has failed. These figures alone do not even convey a sufficiently powerful representation of the uncertainty which still hangs over the determination of the real figure of Mars.

Humboldt, in the third volume of Kosmos, gives two independent determinations by Arago,—the first, $\frac{1}{38.8}$; the second, $\frac{1}{32}$. An eminent Cambridge mathematician thus writes:—" Before speculating as to the cause of the large ellipticity, it is proper to inquire, does it exist? On taking down a volume of the Greenwich Obser-

* See Harte's Translation, vol. i., page 57. 1830.

† Traité d'Astronomie Theorique, tome ii. page 258.

vations, and referring to it, it seemed that the discrepancies between individual observations were larger than the whole quantity in dispute." Professor Challis has even furnished me with two determinations of the ellipticity of Mars, from distinct sets of Greenwich Observations, and whilst these differ as widely from each other as the least and greatest do of these I have quoted, the mean gives a compression of $\frac{1}{86}$. Again, Mr. Hind, in his most beautiful popular work, "The Solar System," after mentioning the statement of Sir W. Herschel, observes:—"But an extensive series of observations recently taken with the best instruments to be found in observatories, gives the compression much less, or the ratio of the diameter, as 51 to 50, which is probably nearer the truth. It is only at the oppositions, or about once in two years, that we see the disc of Mars fully illuminated; consequently, the proper times for determining the difference of diameter, or for any observations upon the appearance of the surface, are not of very frequent occurrence." The rarity of such opportunities, and the great difficulty of determining a difference between the diameters of a planet which subtends an angle of little more than four seconds at the time of conjunction, and while in opposition and perihelion somewhat more than thirty seconds, have, doubtless, led to such conflicting statements,—as the error of a single second, which may reasonably be expected in such observations, would involve more than the whole expected difference. Nor is it surprising that Dr. Maskelyne could detect no sensible difference between the equatorial and polar diameters, and that Professor Johnson, of Oxford, has furnished me with a result tending in an opposite direction. He gives his observations with reserve, and does not attach much weight to them, having been taken at the early period of his connexion with the Observatory; but they are, at least, additional proofs of the great difficulties and uncertainty of the subject:—

1850.	Equatorial Diameter.	Polar Diameter.
January 4,	5.562	6.441
„ 5,	6.145	7.186
„ 7,	5.932	„
„ 13,	5.967	5.881
Mean,	5.901	6.503

The planet was at its mean distance from the earth, and Professor

Johnson observes:—"You see I make the polar diameter exceed the equatorial. Most probably this arises from error of observation, for at best I find it a difficult object."

To me this great discrepancy proves either that, owing to the small size of the planet, one-half that of the earth, no correct measurements have yet been effected, or that there are circumstances connected with its appearances, and even, perhaps, with its substance, which render such determination difficult and dubious; or finally, that Mars has not yet attained a state of perfect equilibrium,—for we may suppose* "that according as compression increases, the motion of rotation will become less rapid; therefore, if there exists between the molecules of the fluid mass a force of tenacity, this mass, after a great number of oscillations, may at length arrive at a motion of rotation comprised within the limits of equilibrium, and fix itself in that state."

Mr. Harte, in his very able notes on Laplace, points out, as Mr. Haughton has done, the two limits within which the compression of a planet should be comprised; and in applying the rule to the Earth and Jupiter remarks, that Laplace had deduced from it an increase of density in Jupiter, from the surface to the centre, just as the observations made on the density of the earth have established to be the fact in our own planet,—a very striking analogy, which may well be added to the many other examples of harmony in the works of nature.

I think, therefore, with such great discrepancies, sometimes rising, and sometimes sinking in amount, I am justified in believing, either that the compression of Mars has never been accurately determined, or that it is variable. But the first of these suppositions is strengthened by the uncertainty which even yet hangs over the compression of Jupiter, the apparent diameter of which is double that of Mars. Humboldt† gives the following measurements of ellipticity, namely, by Arago, in 1824, $\frac{1}{17.7}$; by Beer and Mädler, in 1839, between $\frac{1}{18.7}$ and $\frac{1}{21.6}$; and by Hansen and Sir John Herschel, $\frac{1}{14}$; and if with a planet so large, and which exhibits so clear a light, accompanied by a well-defined outline, it be difficult to determine the compression, well may there be hesitation in depending

* Harte's Notes on Laplace, vol. ii. page 455.

† Kosmos, vol. iii.

upon the determinations as yet recorded, either of the time of rotation, or of the compression, or of the mass of Mars.

Whatever may have been the original state of Mars or of the Earth, I think there can be little doubt that the latter has passed through (in great part, if not as a whole) a condition of fluidity; not, indeed, of such a perfect fluidity as is exhibited by water, but rather in the case of ordinary earthy or mineral matter, the fluidity of a viscous mass, such as is actually observed in the erupted lava of volcanoes. The occurrence of rocks, which by their crystalline and yet compound character must have required the action of some solvent in all parts of the globe, seems to require a cause possessed of equal generality; and though that cause, or the medium of solution, cannot have been water (as appears to have been the opinion of Laplace), there is no apparent objection to the efficiency and generality of heat, whilst such a cause explains most simply the generality of the so-called igneous rocks, and its still continued action, the phenomena of volcanic eruptions. It is true, indeed, that a modern philosopher of the highest eminence attributes volcanic eruptions to the pressure of elastic gases in the surface of internal lakes or reservoirs of melted stony matter, which in his opinion are local, and have no connexion one with the other. But if so, how can the generality of such phenomena be accounted for? Taking into our consideration the trachytic and basaltic eruptions of ancient but well-defined volcanic vents, the vast basaltic flows of submarine volcanoes, the numerous basaltic and other dykes which must have proceeded from molten masses within the crust of the earth, which they have riven asunder,—how can we account for them as merely local and partial? If progressive, how can we imagine that the cause of fluidity should have shifted from place to place, until it had, as it were, spanned the whole earth; and if simultaneous they become general.

The arguments which have been advanced for this partial existence of volcanic reservoirs are these:—The supposed impossibility of a liquid nucleus or liquid annulus in the interior of the earth, under so great a superincumbent pressure; and secondly, the want of any sympathy, as it were, between the eruptions of distant volcanoes. The first I have already discussed, endeavouring to show that the condition of liquidity may be preserved under any pressure; and if I am right it must be manifest that whenever, by a dis-

location of the crust, a local relief of the pressure takes place, the liquid matter within will be ready to yield to the lateral force, and to rise up into the fissure or crack above it. Such, indeed, would be the case, even were there not an actual condition of fluidity, if pressure alone prevented the assumption of that condition, as on the removal of the obstruction the matter condensed would at once become fluid, and nearly the same phenomena be exhibited. In regard to the second objection, it is manifest that the propagation of motion through a body so imperfectly fluid as the molten earthy matter of our globe necessarily is, must be a very slow process, more especially as frequent subsidences from dislocations must occur to check it. The eruption of a volcano may therefore be, and in all probability is, the result in many cases of pressure at a very distant point slowly propagated through the viscous mass, and terminating by an outburst of molten matter, long subsequent to the first impulse which really produced it; and in like manner, the earth-wave, or earthquake, being propagated with greater rapidity through the solid medium of the crust, it may have passed away long before the occurrence of an eruption, the origin of which was actually at the same point and time. It is thus that in my mind the actual earthquake and volcanic phenomena are really connected with each other, their origin being synchronous, though their visible results are not so.

Were it possible to remove the envelope of detritic matter which conceals so large a portion of the probably congelated crust of the earth, it would be easy to estimate the disturbances which it has experienced; but it is now seen only darkly through a veil. Let it not, however, be supposed that the degrading force of water has materially assisted in giving its present form to our earth, as Mr. Haughton supposes it may have done in Mars; for though the sedimentary deposits have been contorted and elevated by internal convulsions, they are in themselves, even including the metamorphic or crystalline schists, a small fraction of the earth's crust in thickness; and when compared with the augmentation of the earth's semidiameter, if we allow them a thickness of five miles, they are but one-half of the difference between the polar and equatorial radii. But, further, let it be also remembered that there are sedimentary deposits in all parts of the world, and it is therefore more than probable that if the action of water has preserved a proportionate increase in thickness of these deposits from the poles to the equator,

it is the utmost effect which can be ascribed to it; and hence, that the real form of the earth had been acquired before the work of degradation had commenced.

In addition to the arguments for a former condition of igneous fluidity of our earth afforded by the wide, or rather general, extension of crystalline massive rocks, and of trachytes, basalts, and other volcanic rocks, as well as by the progressive increase of temperature from the surface of the earth downwards, the existence of insulated crystallized minerals in the heart or substance of rocky masses appears to supply another most important one. Our able member, your former President, Mr. Mallet, has shown us how effectively the experiments of the laboratory may be made the basis for establishing great physical laws, in his researches on earthquakes, or on the transmission of waves through solid media of various degrees of elasticity; and in a similar manner M. Ebelman has illustrated in the laboratory the formation of many of the hardest and most infusible of the precious gems. In my former address I pointed out the researches of M. Daubree on the formation of quartz crystals, &c., through the intervention of chlorine, and the re-action of some other base on the volatile chloride of silicium, using that compound as a substitute for the natural and less easily formed volatile compounds, fluoride and boride of silicium; and there cannot be a doubt that many of the crystals in veins, or which line fissures or cracks, have been thus formed, as there is no appearance of a corresponding action of heat on the containing substances; but these are, to a certain extent, secondary or subsequent to the formation of the sedimentary deposits in which they occur; and though they betray, to a certain extent, some remarkable peculiarities of the internal portions of the earth, they cannot entirely explain the formation of definite crystallized minerals.

About four years ago, M. Ebelman described, in a paper read to the Academy of Sciences, his views of crystallization in the dry way, in which the elementary substances are held in solution by a mineral solvent, aided by great heat; and exhibited some of its most striking results in artificially formed gems. In a second paper* he has now still further illustrated the subject, and formed many rare and precious stones, which, though infusible at the temperature of our

* Read March 3, 1851. Annales de Chimie, Sept., 1851.

furnaces, are found naturally formed in the mineral kingdom; and further, by thus preparing some new crystallized mineral compounds analogous to known species, he has generalized his discovery, and furnished types to which the composition of these species also may be referred. Ebelman proceeds on the same principle as if he had adopted water, alcohol, or even fluorine or borine, as a solvent, selecting, however, a substance which remains fixed at a high temperature, though at a higher it becomes volatile,—such as boracic and phosphoric acids, and some alkaline phosphates. These substances act as powerful fluxes at a high temperature, but are ultimately vaporized, when the substances they retained in solution crystallize. Some of the examples of his last experiments I shall here state. *Zinciferous Spinelle or gahnite.*—In his various trials M. Ebelman found the zinc volatilized in great measure by the heat of the porcelain furnace he used, and hence he failed to produce the required mineral. He now used the muffles of M. Bapterosse's manufacture of paste buttons, and succeeded. A mixture of alumina, 6 grammes; of oxyde of zinc, 5; and of melted boracic acid, 6;—exposed in the muffle for eighteen hours, left crystals of aluminate of zinc, which scratched quartz easily. They consisted of—Alumina, 55.9; oxyde of zinc, 44.1, corresponding to the formula, Al_2O_3, Zn O. And in another experiment, in which a little bichromate of potash was added to the mixture, beautiful transparent octahedral crystals of a bright ruby colour were obtained, some of which measured one-tenth of an inch the side. Cymophane, or aluminate of glucine, was formed in transparent crystals, which scratched topaz, and in length were from 2 to 2¼ tenths of an inch, the specific gravity being 3.759; whilst that of the native cymophane of Brazil is 3.734. This mineral, therefore, could be prepared sufficiently large for the cabinet of a mineralogist. Chromates, ferrates, and magneso-borates were similarly formed; but let me turn to silicates. Peridot, or silicate of magnesia, resembling that of Vesuvius, was formed from a mixture of silica, 4.50 grammes; magnesia, 6.15; boracic acid, 6.00, the result being a composition corresponding to the formula,—Si O_3, Mg O; or silica, 42.6; magnesia, 57.2; with traces of oxyde of iron. These crystals had the vitreous lustre and hardness of native peridot, and *were infusible* by the blow-pipe; their density was a little less, as they contained less oxyde of iron. Alumina was obtained crystallized, with all the properties of corindon (corundum).

It is unnecessary that I should follow M. Ebelman through all his labours, or give the entire list of the minerals he produced. But one passage in respect to aluminates deserves especial notice:—"If the metallic borate is fixed, and if the affinity of the alumina for the base is not sufficient at the temperature of the furnace to expel the boracic acid combined with it, the alumina crystallizes in a state of purity in the midst of the fluxed matter, whether borax and silica, borax and barytes, lime or oxide of manganese; and if the affinity be sufficient, aluminates of the several bases are formed. How strong is the resemblance of this first case to that of the crystallization of felspar in a more fusible felspathic paste, so common in porphyries."

M. Ebelman observes with justice, that by this beautiful process the chemist is able to establish the true types and formulæ of mineral species, as the specimens he produces are in a state of purity, which can rarely be the case with native minerals; and thus to introduce a greater precision in the grouping of such species; and, acting on these results, he unites the diallages with the hornblendes. Well may M. Ebelman say—"That by such researches we shall obtain much valuable notions of the origin and conditions of crystallization of mineral species;" and, I will add, an illustration of the real condition of the matter of the earth in which such processes have been carried on.

To this description of inquiry I attach all those investigations which lead to the recognition of general action, whether chemical or physical, as they must in the end afford us a more correct knowledge of the manner in which the earth has been brought to its present state. I have before dwelt at some length on the labours of M. Delesse in this branch of what may be called chemical geology; and have shown the bearing of M. Rammelsberg's researches on the same question. Mr. Haughton has entered on the same field with the latter chemist in his comparisons of the serpentine of Cornwall and Connemara, being aided in his analysis by another of our members, the Rev. Mr. Galbraith. From careful analyses of a Cornish specimen, and of one from Ballinahinch quarry in Connemara, it appears that their composition is conformable to the formula deduced by Rammelsberg from a mean of thirteen results from different localities,—viz.:

$$2\,[(3\,MgO,\ 2\,SO_3) + 3\,HO] + 3\,(MgO,\ HO).$$

When, therefore, we consider that this mineral is itself magnesian, and is invariably associated either with magnesian rocks of an igneous character, or with distinctly metamorphic rocks, the change in which can scarcely have been effected without the agency of heat, such results are most valuable as bearing on the great question already discussed. This is even more the case when we consider the other result of Mr. Haughton's inquiry,—namely, that the red earthy base of the Cornish porphyry is identical in its chemical relations and constitution with the Galway serpentine, as it affords another illustration of the processes described by Ebelman, on the grand scale of the laboratory of nature.

Dr. Apjohn has contributed a very interesting notice of a new mineral compound brought under his notice by George M'Dowell, Esq., one of the Fellows of our College. It is represented to have been part of a central mass or nucleus, within a lode or bed of sulphur ore discovered in the Ballymurtagh district of the county of Wicklow; and on analysis proved to be a compound of simple or basic sulphurets of the three metals, iron, lead, and zinc, mixed up with a portion of the ordinary bisulphuret or iron pyrites of the lode, and represented by the formula—

$$FeS + PbS + 6\,ZnS.$$

The importance of sulphur as one of the great agents in producing some of our most valuable metallic ores necessarily strikes the philosophic geologist; and knowing, from its appearance amongst volcanic products, that it still exists in large quantities within the earth's crust, he cannot but watch with curiosity every phenomenon connected with it. At present, it is known that this elementary substance, when subjected to great heat, loses its fluidity, and assumes at a certain temperature a condition of viscous liquidity quite analogous to that of earthy matter when thus dissolved; and it may, therefore, be associated with lava or any other volcanic product when not in a condition to take fire and burn. The action, also, of a simple combining body on the metallic bases, associates it with chlorine, fluorine, borine, &c.; and it must therefore be received as one of the principal agents used by nature in modifying the earth's crust. This remarkable separation, therefore, of a distinct or definite mineral compound from the mass of the bisulphuret of iron is deserving of much reflection, and seems to imply some very peculiar

condition of the lode, which permitted a free exercise of chemical affinities and re-action. I think that much light would be thrown on the natural process by subjecting sulphurets to the action of intense heat in vessels from which air was excluded; and by whom could such experiments be better conducted than by my learned friend, Dr. Apjohn?

The papers of the present session have been principally of a physical character, describing remarkable phenomena, but not adding to our knowledge of the natural history of the epoch connected with them; and I much regret that our members, from that bias which they necessarily receive in their collegiate course, seem too much disposed to rest satisfied with such descriptions, which, however valuable, are only a part, and a small part, of geological science; however, I hope that the precepts and example of the able naturalist whom you have elected to occupy your Chair will bring back the inquiry (in part, at least) to the investigation of the zoology of our strata, and to the perfecting of our lists of organic remains, without which we must continue to reason on very imperfect data.

Mr. Haughton, in his paper on Rathlin Island, points out many interesting facts. He shows that the general dip of the chalk is from S. to N.; and as that of the chalk on the opposite side is from N. to S., we may assume that though the chalk of Antrim and Rathlin is overlaid by basalt, it has also been uplifted by it. This is consistent with the facts Mr. Haughton describes,—namely, that fragments of chalk are found in the dyke which runs up the valley west of the church, and that the basalt is intermixed with the chalk; and with a similar fact I described in my Geological Report, where a large block of basalt exists isolated in the chalk cliff. Mr. Haughton enumerates and describes several dykes which he considers to correspond with the dykes of Ballycastle, and not with those of Kenbane Head, as stated by Buckland and Conybeare. He describes a bed of lignite at Dunangael; and a bed of ironstone and several faults at Kebble Head, in a bed of ochre, which deserve especial consideration, as the general character of the strata differs so essentially from that of the clay and other strata in which faults so commonly occur. Perhaps the most interesting portion of this communication is that in which the author describes his experiments on some long basaltic pillars, and the determination by them that these pillars possessed distinct magnetic polarity, the upper end corresponding to the north pole of the magnet. The magnetic condition of rocks

has only recently engaged the attention of geologists, although it must now be evident that the stability of the universe depends on the balance between the paramagnetic and diamagnetic conditions of its constituent parts.

The joint paper of Dr. Sidney and Mr. Medlicott, on the Neighbourhood of the Town of Wexford, is in like manner unconnected with any zoological data. The limestone in the neighbourhood of the town is magnesian, and alternates with beds of shale; and it is worthy of remark that a large portion of the lower carboniferous limestones of the south of Ireland possess this magnesian character. Much of the limestone is highly crystalline, and full of small cavities, which sometimes contain very pure native sulphur. The limestone is conformable to the old red sandstone and conglomerate, which appear in the flanks of the hills south-west of the town, whilst the strata of the quartz rocks and clay-slate hills dip in a different direction to those of the limestone and old red, and at a higher angle. This is a point which should be carefully examined, in order to determine the correct geological formations of these several deposits.

In the last session of last year Mr. Haughton brought before the Society some examples of angular fragments of granite found in a bed of limestone opened in a quarry near Crumlin, county of Dublin. Such cases have been recorded before, but, as Mr. Haughton remarks, the fragments are here confined to a single bed, not occurring in those either above or below it, so that the force which removed and deposited them in the calcareous mud was only exerted during a limited portion of time. The nearest granite *in situ* is at Killikee, four miles distant; but to determine the exact nature of the phenomenon, it is necessary to know whether the line of dip or the line of strike is in relation to the granite. If the former, may not this be an ancient example of that description of mud slip which Mr. Mallet has explained? In a specimen obtained from a gravel bed, the enveloping limestone was a dolomite; but this condition was most probably due to a subsequent change similar to that which has been effected on the crystals of felspar of the granite. Mr. Haughton gives an analysis of the limestone boulder which contained the granite fragments, and reduces his analysis to the formula—

$$7\,(Ca\,O,\,C\,O_2) + 6\,[(Mg\,O,\,Fe\,O),\,CO_2];$$

whilst he finds by an analysis of the dolomite from between Williamstown and the Rock station, that its composition is represented

by the same formula, though the composition is very different in the proportions of iron and magnesia;—in the first the proportions of carbonate of magnesia and carbonate of iron being as 35 to 1; and in the latter 26 to 12; and hence Mr. Haughton concludes, that the boulder did not come from that locality of the dolomite rock. But surely such reasoning cannot be admitted in geology; and as the boulder contained fossils, a better means of comparison might have been found in them. When we consider that the chemical action is here between the particles deposited as confused mud, we might well expect that these isomorphous compounds would vary at distances of even a few yards, or even in every specimen. The identity is, in fact, more nearly approximated to than might have been expected, as the proportions of argil are actually 14.64 to 15.66; and we must take care not to discredit this most valuable auxiliary to geology by applying it to the determination of geological questions beyond its reach.

Mr. Jukes's paper on the Geology of the South Staffordshire Coal-fields is one, also, which merely deals with the physical phenomena; but in this case, as the English formations have been so fully worked out, the deficiency is of less importance. Having shown the manner in which the carboniferous rocks dip under at both sides, the new red sandstone which lies between the Penine chain and the mountains of North Wales, and pointed attention to the insulated coal-fields of Leicestershire, Warwickshire, Staffordshire, and Shropshire,—in the latter of which the mountain limestone and millstone grit and Devonian shale are almost wanting, the coal measures resting on Silurian, or even more ancient strata;—he describes in detail the South Staffordshire or Dudley Field.

In this district the new red sandstone, carboniferous and Silurian strata, are all present. In the Silurian, soft shale predominates, having near the summit a twenty-five feet band of argillaceous nodular limestone, referred to the Aymestry limestone; at 1000 feet below, one or two bands, each 30 feet thick, referred to the Wenlock and Dudley limestones; and at 1500 feet lower, another band, 30 feet thick, referred to the Woolhope limestone, the top of the Caradoc sandstone appearing in one part of the district still lower. The coal formation is here made up entirely of *coal measures*, and is 1500 feet thick. It really contains about twelve distinct beds, which are, however, in some places brought together, so as to form, apparently, one bed 30 feet thick. Besides the stratified

rocks, there are several varieties of igneous or trap rocks, such as basalt, porphyritic, greenstone rocks, which are rarely wanting in disturbed districts; and this, though in part its tranquillity seems to have been unaffected, has not escaped disturbance, as is manifested by numerous faults. It is thus that in some places there is a perfect conformability between the new red and the coal measures, whilst in others the latter, and sometimes the Silurian strata below are seen tilted up, and cropping out at high angles; and Mr. Jukes points out the caution which such variations teach the miner to use in his estimates of the probability of finding coal under the new red sandstone, as it may happen that in some cases the Silurian strata alone may be found under it. Wherever, indeed, there are indications of internal disturbance, the geological problems of mining become complex, and require the greatest skill in their solution. Mr. Jukes records his discovery in 1850 of lias beds in Needwood Forest, and states his opinion that, as lias exists here and in Cheshire, it is probable that all the midland counties were once a great lias plain, and that the great boundary faults of the coal-fields are newer than even the lias. Such speculations are interesting, but it should be remembered that the lias was a marine deposit, and probably subject to many modifications and disturbances during its deposition.

The last paper I shall notice is a mineralogical one by Dr. Apjohn. It contains the analysis of a mineral purchased by Rev. Professor Jellett from a mineral dealer in Switzerland. Mr. Jellett suspected that it was new, and his suspicion was confirmed by Dr. Apjohn, in whose laboratory it was analyzed by one of his pupils, Mr. H. Wright. It forms a species of crust of a dull greenish-yellow colour, on the surface of an indurated talc schist, which contains brown granular garnets, and has white asbestos adhering to it. It scratches quartz, has a compact fracture, but is composed of numerous aggregated prisms, with rhombic bases, the angles of which are 60° and 120°. Its specific gravity is 3.741. The composition from two analyses is represented by this formula—

$$4\,Si\,O_3 + 2\,Fe_2\,O_3 + 5\,Ca\,O.$$

To reduce this to a rational formula, Dr. Apjohn first considers the peroxide of iron as performing the part of a base; but in this case it would be necessary to admit a form of silicate of lime, for which there is no analogy,—namely, two atoms of silicic acid, combined with five of lime; and he then views the peroxide as

an acid similar to the isomorphous substance, alumina, when the formula

$$2\,(CaO, 2\,SiO_3) + 3\,CaO, 2\,Fe_2O_3$$

is obtained, representing a compound consisting of a bisilicate of lime and a sub-sesquiferrate of lime, a compound which, Dr. Apjohn considers, may be readily admitted, as it has numerous analogies in its favour. This new mineral Dr. Apjohn names Jellettite, in honour of the distinguished mathematician who submitted it to him for examination. It is impossible not to perceive in this analysis matter for very interesting speculation. The very function which the peroxide of iron assumes in this compound is remarkable, and whilst it indicates how readily nature provides for all contingencies in the mineral kingdom, consequent on the confused mixture which takes place under the varied action of physical forces, it also shows that every combination is tied down by the most definite laws, and conforms to fixed types of mineral species. The character of this mineral as an incrustation is also curious; and as it occurs on a rock admitted by all geologists to be metamorphic, we may fairly assume that it also is a product of some specific action on the talcose rock, which has induced a new interchange of chemical affinities between some portion of its elements. It would be well in every such case to examine the rock immediately connected with the crust, as well as that at some distance from it, in order to have the limit of the change, if such has taken place.

Before turning to the communication of Mr. Mallet, I think it right to close this part of our subject, which is, in some degree, of a cosmical character, by a brief notice of the researches of Mr. Hennessy, as published in the Philosophical Transactions.* Mr. Hennessy's paper is entitled "Researches on Terrestrial Physics." He justly observes that little has been done in maturing or improving the hypothesis by which the figures of the heavenly bodies are theoretically explained since Clairaut published his unrivalled work on "The Theory of the Figure of the Earth." It is surprising that such should have been the case, and equally so that geology should have gained so little advantage from the theory of fluidity, a circumstance which Mr. Hennessy attributes to the limited view taken of the hy-

* Part II. for 1851.

pothesis,—namely, in considering that "the volume of the whole mass, and the density of the fluid, have not been changed by the solidification of a part of that fluid,"—a restriction which Mr. Hennessy does not consider entirely consistent with what is known of the solidification of fluids.

Having examined mathematically the general questions connected with the figure of the earth as an ellipsoid of revolution, Mr. Hennessy enters on the consideration of that change of general conditions which would result from the refrigeration or consolidation of a mass of heterogeneous substances reduced to or held in a fluid state by intense heat; and he assumes that whilst in such fusion chemical action would take place, leading to the formation of various compounds, which, according to their densities and compressibilities, would be arranged around the centre of gravity of the spheroid, until "at length the mass would consist of a series of spheroidal strata, each of uniform density throughout its own mass, and having that density expressible as a function of its axes." It does, indeed, appear to me that in the case of the earth, where the figure has been proved to be that of the ellipsoid of revolution, which corresponds to that of a fluid in motion round an axis, and where the variations of the force of gravity at the surface, except in cases of manifestly local disturbance, correspond also to such a theory, it is impossible to conceive any material deviation from this supposed regularity of internal arrangement; whilst the fact of such comparative regularity in the force of gravity proves the comparatively small thickness of the sedimentary and variable deposits of the external portion of the earth's crust. Mr. Hennessy then explains his views of the changes in density which must take place in the circulation of the strata of the fluid upwards and downwards, according to their loss of temperature above, or gain of temperature below. But here I must suggest caution, as it does not appear to me that we know sufficiently of the process of refrigeration, or of that of fusion in bodies which only attain a viscous fluidity, to assume that there is such an interchange of the strata of different temperatures as is observable in more perfect fluids. It is, indeed, more probable, that in the course of radiation of heat through a viscous mass, the nucleus has imparted its heat upwards, and has become solid as well as the crust; and if this be so, the time may come when the whole of this heat shall have been dissipated into space,

and the earth shall have become entirely a solid, at a very low temperature. May we not, indeed, imagine that the partial interruption of the passage of heat from the accumulation of badly conducting materials may have produced the glacial period of our geological system, and that the consequent accumulation of heat having at length melted these substances at their lower portions, the temperature has again risen, or perhaps is even now rising? Such, indeed, appears to me one not improbable cause of the variations of climate in past geological epochs, and one, too, which will explain the local variations in deposits of the same epoch. Mr. Hennessy has himself considered this case of a solid nucleus and crust with a liquid annulus; but it would be out of place to follow him here through the able analysis by which he searches for truth amidst the difficulties and obscurities of geological data; and I shall therefore now content myself with stating one remarkable result at which he has arrived, namely, that admitting the theory of a consolidated crust, the least possible thickness of that crust cannot be *less* than 18 miles, or *more* than about 600,—a result which appears to me very consistent with geological observations, and with a deduction I had arrived at from other considerations, as it appeared to me not necessary to assume a much greater depth than 100 miles for any igneous product with which we are acquainted. Mr. Hennessy has also shown that the original or fluid ellipticity of the earth was *less* than its present ellipticity; and I have little doubt, therefore, that he will hereafter be able even to reconcile the supposed form of Mars to the theory he has adopted, and that, too, without any hypothesis more arbitrary than the one which our learned Secretary has been obliged to assume in order to make it conform to the solid theory. He has also shown mathematically that there must be great friction at the junction of the crust and liquid nucleus; and further, that the evolution of gases from the strata diminishes as the thickness of the crust increases,—results which to me appear quite in conformity with observed facts, as the former evolution of chlorine, iodine, bromine, &c., must have been very great, if we judge of it from the amount of their products in combination in all parts of the earth.

In judging of the value of the researches and deductions of Mr. Hennessy, it is right to remember that Mr. Hopkins has come to very different conclusions in the second and third series of his Researches, published in previous volumes of the Philosophical Tran-

sactions, as to the least possible thickness of the crust of the earth, making it from thirty to forty times as great as that deduced by Mr. Hennessy; and as Mr. Hopkins's reasonings are founded on the necessity of reconciling this thickness to the various astronomical phenomena exhibited by the Earth in its rotation round its axis and revolution round the Sun, it is evident that the hypothetic assumptions of Mr. Hennessy must be carefully investigated, not merely as regards their probability *per se*, but also in respect to their harmony with great general results, before they can be received as a safe foundation for cosmical deductions.

Before leaving this higher branch of physical geology, I must regret that, not having seen in print the second part of Mr. Mallet's Report on Earthquakes, I cannot give that analysis of it which its great merits require. I may, however, observe, that I cannot see in the distribution of volcanic vents, as described by him, from the authority of various writers, any argument against the theory of elevation of mountain chains advocated by M. Elie De Beaumont. If placed on a map, and united by a line extending continuously one from another, they may, indeed, seem to indicate spiral or circular lines; but no one, I am sure, would for one moment consider that the axes of disturbance assumed such strange directions. The volcanic vents are, on the contrary, situated more probably on each side of an axis of disturbance, or in an area of disturbance, and may assist us in discovering that axis, though they do not actually mark it out. Two different kinds of talent are valuable in geological research,—that of patient elucidation of principles, so powerfully exercised by our esteemed member, and that of philosophical generalization, so eminently possessed by M. De Beaumont. Let both be applied, but let neither be undervalued nor neglected.

I must now turn to a subject painful to myself,—namely, the complaint which my friend Mr. Mallet has made, that from "an imperfect knowledge, apparently, of what the precise nature of his views were," I have unjustly denied to him the merit of originating a peculiar theory of the movement of detritic masses, and of their effects in grooving of rocks, &c. Assuredly I should feel ashamed were it possible for me to do injustice willingly to one so gifted and so honoured as my friend and fellow-labourer; but I must repeat, that my own conception of his original ideas on this subject, and, I may add, the conception of some of our most able members, was,

that Mr. Mallet's theory referred to the movement of semifluid masses of mud, gravel, &c., over the dry land, being, therefore, analogous to land slips; and I think the term "mud glaciers" could have no other reasonable application. In such a mind, however, as that of my friend, other ideas may doubtless have been floating, though not as yet fixed and reduced to order; but when we remember that he never reduced his ideas into such a shape as permitted their publication either in our own Journal or elsewhere, it would, I think, be a dangerous precedent to allow that the mere expression of these first thoughts was to act as a bar against the research of others, or to entitle their author to claim the discoveries even founded upon them. When I spoke in my paper on Bantry Bay of the extreme probability that the scratches on the rocks I there described had been made by pebbles moving in and with the great mass of boulder, I expressed only a fact, not a theory, though I certainly had my own speculative opinions on the subject. My arguments, therefore, on the point of originality were not personal as regards myself, but were just as regards the able writers who had discussed the subject of the movement of detritus, whether on the dry land or under water. Mr. Mallet has now explained (June 11, 1851) his theory, in the following manner. Assuming that the rocky skeleton of the earth has been gradually raised up with a coating upon it of detrital matter, he asserts that this matter will be gradually passed downwards from the higher lands by the formation of successive lines of temporary coast beaches within the limits of wave and tidal action, and "that successive slippages or slidings out, *en masse*, of loose materials, such as sand, mud, gravel, or earth, often bearing large boulders, will continually take place along every such coast, at the steep taluses formed along them by the tidal or wave action;" and the distribution of these materials "will again produce other similar slippages under water, and produce upon the subjacent rocks the phenomena of scratching, furrowing, rounding, &c.," and "simulate all the principal traces of glacial action, for which, and for evidence of a supposed arctic or glacial period, I consider they have been frequently mistaken." It is to such movements of detritus that Mr. Mallet now says, "he first gave the name of mud glaciers," —that is to say, "to masses of slipping materials whether under water or above water." Further, Mr. Mallet states, as a corollary to his first proposition—"that around all the existing coasts the for-

mation of such masses of loose materials, and their continuous or intermittent slippages, are in daily progress, and that the grooving and furrowing of rocks beneath is now taking place thereby, and the transport within such masses of large boulders detached from sea-cliffs, which are thus gradually transferred into deep water, and often to vast distances over the floor of the ocean, whence they would emerge, and be left isolated, if at a future time such floor should become dry land." I need not follow Mr. Mallet further than to state that he represents denudation not as the result of any debacle such as a sweeping away, but as a cutting away by current action, and the movement of the mass "bodily by a *vis a tergo*,—namely, the weight of the mass itself of loose materials acting as a semi-fluid or plastic body, bearing and carrying along with it included boulders, stones, &c."

Such, then, is the theory of Mr. Mallet, as now proposed. The facts are undoubted, and must have been observed by every one who ever looked upon a sea-coast on which the sea was encroaching; but are they adequate as a cause to account for the grooving of rocks and the movement of boulders? Has any one ever observed scratches or grooves produced by land slips, or by mud debacles on land? and is it probable, therefore, that any semifluid mass slipping down under water could produce such effects? Is the removal of matter by the action of currents, so often observed and recorded in our tidal rivers, conducted in this way, and is it not rather by the falling in of the top so as to produce a bank towards the wave? Much use may, doubtless, be made by the geologist of such movements, and, doubtless, both land and coast slips, combined with shifts of banks, have occurred at all geological epochs; but I think few will recognise in this agency a cause which will account for the removal of massive boulders and the distribution of detritus over lines 200 or 300 miles long, or even for the formation of the grooves and scratches of rocks which often occur in positions which cannot be reconciled to such a theory. If Mr. Mallet had gone one step further, he would have included the speculation present in my mind, and it is even probable that he did intend to do so. That view is this: that such masses of matter could only produce such results by their motion when consolidated by great pressure, and hence, that when by internal disturbance undulations of the deep sea-bottom were formed, the consolidated mass might slip along the now inclined sur-

face, and, holding firm the imbedded pebbles, groove the subjacent rocks. Such masses, also, might be firm enough to hold boulders on their surface, which assuredly they never could do when semifluid along a sea-coast. Even this modification or extension of Mr. Mallet's is only sufficient to account for some peculiar cases of grooving, and not for the more general phenomenon. Mr. Mallet's reputation is too high, from researches of a truly original character, to require any support from so uncertain a theory.

It does not, indeed, appear possible to limit the number of formative and modifying causes which have acted from time to time in producing the results we now observe in the present condition of the surface of our planet. Something new may be discovered from the observation of almost every local phenomenon. M. Le Colonel Joaquin Acosta has in this manner studied the curious mud volcanoes of South America, and communicated very interesting information respecting them.* It appears from his statement that the gas issuing from these volcanoes is not, as Humboldt supposed, nitrogen, but carburetted hydrogen, having a bituminous odour, which it derives from the petroleum which oozes out at the surface of the mud. Colonel Acosta considers the mud volcanoes of Turbaco as connected with the great phenomenon of mud volcanic vents so fully developed on the coast of the province of Carthagena, and having as a focus the volcano of Galera Zamba. Colonel Acosta had previously described the destruction of the Trachytes of Ruiz, and the mud inundations of the central Cordillera, and he now states, that on descending the Madalena he satisfied himself that the mud of various great inundations of this volcanic character had been consolidated at successive epochs along the course of that river. It is in this manner that the ordinary superficial gravel or drift has been covered over by a trachytic conglomerate. M. Acosta promises a chart of the Madalena, in which these curious deposits, which diminish in extent as the river approaches the sea, will be exhibited and explained; and I cannot but anticipate much instruction from it, as there can be little doubt that similar eruptions and deposits have occurred at many past geological epochs.

In turning now to the organic branch of geology, I feel that I should not be justified in dwelling long upon it, as the labours of

* Annales de Chemie, January, 1852.

our Society have not been directed towards its extension or elucidation during the present session. It is impossible to repeat too often my expression of regret, that a branch of inquiry, which is so essential to the determination of individuality in formations, should have been thus neglected, or my hope that the charms of cosmical speculations, even though they may be founded on sound analytical deductions, will not much longer seduce our members from the investigation of the laws of organic creation.

In my Address of last year I drew your attention to the monograph of Permian Fossils by Mr. King. This geological system or formation deserves some further remarks, as it affords another example of the successful generalization of Sir R. I. Murchison, only second in its importance to his still more remarkable Silurian system. It is well, however, that we should first clearly understand the characteristics which ought to be required in every geological system, and these are, that both the physical and organic conditions should be represented. So long as the apparently insignificant deposits of the German Zechstein and English Magnesian limestone could alone be quoted as evidences of a distinct epoch in the history of creation, it would have been rash to attempt the establishment of a system; but when Sir R. Murchison discovered in Russia examples of the varying results of the several forms of action which must ever be simultaneously at work on the earth's surface, and lead to corresponding deposits, it was manifestly safe to attempt a great generalization, and to include these partial deposits in one great system. Sir R. Murchison did this, as he had previously done in respect to the Silurians, and now the Permian system has been adopted by all geologists. Dr. Moritz von Grüneweldt* has, in papers read before the Geological Society of Berlin, contributed some very interesting additions to our knowledge of this formation. Von Dechen had previously stated that the Zechstein continued into Silesia on the north slope of the Riesengebirge, and Dr. Moritz has now described the fossils collected there by himself and Professor Beyrich. He justly observes that in this formation, as in every other formation, local variations in the fauna must be expected, for were it not so, the conditions of the ancient world must have differed entirely from those of the present; or, in other words, nature

* Journal of the Berlin Geological Society, May, June, July, 1851.

must have acted then according to different laws than those by which she is now regulated,—an hypothesis which finds no support from the observation of facts. Making allowance, then, for this natural difference, the fauna of the world at this remote epoch exhibits a very striking similarity at the three points of observation, Russia, Silesia, and England, which appear to have fallen either on the margin of the Permian sea, or on some shoal adjacent to its shore. The numbers examined and identified by Dr. Moritz were—

Cephalopoda.—One species, common to Russia, Silesia, and England.

Gasteropoda.—Two species, common to Silesia and England.

Conchifera.—Six species, common to Silesia and England, of which three species are common also to Russia.

Brachiopoda.—Productus horridus, England, Silesia, and Poland; Terebratula elongata, common to Russia, Silesia, and England.

Crinoids.—Cyathocrinus ramosus, common to England and Germany.

Bryozoa.—Two species, common to England and Germany.

Polyps.—One species, Germany.

It is manifest that so far as these limited data of comparison permit us to judge, the analogy of the fauna of Permian Germany was nearer to the English than to the Russian type of the epoch, though at the same time there is ample evidence of its close relation to that of Russia. I may here, perhaps, with advantage make some few remarks on the use of these geographical terms, Permian, Silurian, &c., for the designation of geological formations. It appears, indeed, to be a very wise arrangement, as it points at once to a typical district in which such formation has been found fully developed, and, in consequence, has been there studied with advantage. The practice is every day gaining ground, and M. Alcide d'Orbigny has in consequence given such geographical names to all the subdivisions of both the oolitic and the cretaceous systems. To make the method, however, really valuable, it must be remembered that the importance of the district itself, in any other than a geological sense, has nothing to do with the question, and, consequently, that the system of Siluria may be reasonably extended over Cambria or Wales, and that of Permia over Germany and England. There is, indeed, no logical inconsistency in this, for whatever may be the

present relative geographical importance of districts, by the geologist their value must be determined by the comparative development of their organic inhabitants at that ancient epoch which may be the subject of study. The propriety, therefore, of extending the local names of Bath, Kimmeridge, &c., where some peculiar fauna has been studied with advantage (though they may not be so harmonious as those of Siluria and Permia), over continental districts of probably greater geographical extent and importance, will not, I think, be disputed by any modern geologists.

The "Traitè Elementaire de Conchyliologie" of M. Deshayes, which promised to be so valuable an auxiliary, both to the pure conchologist and to the geologist, has been again resumed, after a long suspension, in consequence of the author's absence in Algeria. The last part begins with the important family "Cardiaceæ," which M. Deshayes still restricts to the genera Cypricardia, Isocardia, and Cardium, as he had done in "L'Encyclopedie Methodique." After pointing out the erroneous extension of this family by some writers, and its equally erroneous restriction by others, he quotes the authority, in terms of justly merited praise, of Professor Edward Forbes and Mr. Hanley:—"In their excellent work," he says, "on the Mollusca of Great Britain, they have been led by similar facts to the same conclusions; and there is every reason to believe that their opinion will be confirmed in proportion as observations shall be multiplied." In approaching a family so familiar to us in our existing fauna, we appear to be entering on known ground; and every species we meet becomes interesting, as it admits of a direct comparison. Commencing with the genus Cypricardia, M. Deshayes points out that though the hinge may in living species be always trusted as a sufficient character, the modifications from age being slight, it cannot be trusted in the examination of fossil species, of which many, having no teeth, exhibit all the internal peculiarities which mark a similarity of structure in the more important organic elements. Although, however, this view of the superior importance of the more purely zoological characters is quite in accordance with the philosophic systems of modern zoologists, it would be unwise to overlook so great a variation in the structure of the hinge of the shell, and not to draw from it, as a conclusion, that the change from a condition in which there were no teeth to one in which the teeth are strong and highly developed, at least points out some pe-

culiar adaptation to circumstances which have undergone a similar variation. In the genus Cypricardia M. Deshayes places the greater number of the fossil species of Sanguinolaria, and powerfully contends against the opinions of M. D'Orbigny, who has allocated many of them to his genus Lyonsia. The species he thus distributes:— To the Lower Silurian he gives seven, some of which have been found in America, some in Russia, and one only in England; and to the Upper Silurian twelve species, six of which have been described by Mr. Hall in his "Palæontology of the State of New York;" five have been found in England, including the *Cypricardia impressa* of Phillips, which extends into the Devonian; and one, the *C. inflata* of Eichwald, which was first discovered in Russia, but has since been found in Belgium and England in the same zoological position. The Devonian is very rich in species, twenty-two having been described, in which number nine Sanguinolariæ of Goldfuss are included. They are spread over America, Russia, Germany, and England; some species, such as *Cypricardia cymbæformis*, being common to England and Russia, whilst, on the contrary, not one appears *to have passed the ocean* from America to Europe, as has been observed in species of other genera. The *Cypricardia striata* (*Sanguinolaria striata*, Munster) passes from the Devonian to the Carboniferous, having been found simultaneously in the Eifel, and at Visé, in Belgium. Thirteen species have been recorded from the Carboniferous, the greater number from Belgium. Of these, four species are peculiar to England and Ireland, and three deserve especial notice, as they extend from Belgium to England, namely, *C. parallela*, *C. squamifera*, and *C. rhombea*, the latter being also common to Russia. M. Deshayes also suggests that the shells of Australia, collected by Mitchell and Strzelecki, and described by Sowerby under the generic names Megadesmus, Pachydomus, Orthonota, Euridesmus, and Allorisma, should be placed in this genus, the thickness of the ligament not being a sufficient character to establish generic distinction. At this geological stage the genus appears to have been curtailed in its development, as the Permian has produced only one species, the *Cypricardia bicarinata* of Keyserling; and the *Muschelkalk* (of the Trias), usually so rich in fossils, also only one, according to Deshayes, the *C. gregaria*, although M. D'Orbigny admits four species.

In the Oolitic formation—a series of formations—the number

of species rises to nineteen, or rather to twenty-two, including the three new species which M. Deshayes now describes for the first time. Six species are peculiar to the Lias of France and Germany, and one species, the *C. terea*, appears confined to the Lias of Lorraine; seven species are found in the lower Oolite,—namely, two in England, one in Germany, and four in France; and of the latter, the *C. cordiformis* of Deshayes has so wide an extension as to characterize the deposit, having been collected in Normandy and Lorraine. M. D'Orbigny has discovered one species in the "Bathonian section" (the Bath Oolite); two other species extend from the middle Oolite to the lower portion of the "Oxfordian section;" three species being cited in this latter section; and M. Deshayes points attention to Vieux Saint Remi as a locality where its fossils can be studied to the best advantage. Two species are known from the Coral Rag, having been described by M. Bruguiere, in his work on the Geology of the Department of the Meuse.

The Chalk is very poor in species, having yielded not more than one or two species, and Professor Edward Forbes has described one, *C. undulata*, from the Greensand. The Tertiary strata are also very poor, four species having occurred in the lower Tertiaries, one of which, the *C. pectenifera*, has been found both at Barton and in Belgium; and two others are peculiar to the Paris Basin; two species in the Miocene of Europe, as described by M. Grateloup; and one in the Miocene of North America, the *C. arata* of Mr. Conrad; and three species in the upper Tertiaries, each of which has its living representative,—namely, *Cypricardia coralliophaga* (Lamk.); fossil in Sicily, Italy, and the neighbourhood of Bordeaux and Dax; living in the Mediterranean, *C. Mediterranea* (Desh.), allied to the preceding, but always more wide and short; it is lithophagous; fossil, it occurs in Italy and at Navarino, where it was discovered by M. Jeangerard; *Cypricardia oblonga*, *Chama oblonga* (Linn.); fossil in the recent Tertiaries of Egypt; living in the Red Sea and Indian Ocean.

It is thus that this genus was at a high state of development at the very earliest epochs of the earth's organic history; became then suddenly restricted to a very small number of species, but continued to exist up to our present creation, in which, however, it is represented by only seventeen species.

In contemplating these very remarkable variations we must not

forget the remark I have made at the outset,—that the early type of the genus was found in shells which had toothless hinges, and the recent type in those which have fully developed teeth; so that it would appear that there really is a very strongly marked line of demarcation between the ancient fossil and the recent shells; the genus having been renewed on a new type of structure.

The genus Isocardia first appears in the Devonian strata, from which eight species have been obtained; one, *Isocardia tanais*, having been discovered in Russia by M. de Verneuil, and the others in Germany and England. The Carboniferous strata have supplied three species: two from Belgium, and one, *I. oblonga* of Sowerby, common to Ireland, England, and Belgium, and therefore characteristic of the formation.

The *Muschelkalk* (Trias), including the formerly disputed beds of Saint Cassian, in the Tyrol, has yielded nine species, all from that once celebrated locality.

The genus now diminishes for a time in importance, four species alone, and all of them not restricted to this particular section, having been obtained from the Lias; nine from the lower Oolite, some of them being of doubtful relation to the genus; four species from the great Oolite, one of which, the *I. rostrata* of Sowerby (not Goldfuss), is common to Germany and England; eleven species from the Oxfordian beds of various parts of Europe, of which *I. tenera* of Sowerby is common to France, England, and Switzerland. One species only has been satisfactorily determined from the Coral Rag, and one from the Kimmeridge section. The Chalk has yielded nineteen species, and the Greensand four; and the *Isocardia cretacea* of Goldfuss deserves especial notice, having been found in Germany, England, and recently by Mr. Sharpe in Portugal. The Tertiary strata are less rich in species, as they have only yielded fourteen species, including the still living *I. cor*. The *I. sulcata* of Sowerby is peculiar to the London clay, and the *I. Parisiensis* to the *calcaire grossiere* of the Paris Basin; the *I. crassa* is common to the Crag of England and Belgium, and the *I. rustica* of Conrad is the American representative of *I. cor*. Of recent species, the *I. cor.* alone is found fossil; it first appears in the Crag of England and Belgium, and in the more recent Tertiaries of Italy, Sicily, the Morea, Cephalonia, Algeria, and Perpignan.

The genus Cardium is one of the most important and widely

diffused in nature, and is retained by M. Deshayes as it was left by Linnæus, Bruguiere, and Lamarck; the subsequent dismemberment into the genera Cardissa, Pleurorynchus, &c., being in his opinion unjustified by true zoological characters. Of this genus, 150 living species have been described, and about 500 fossil species have received distinctive names, though, without doubt, a very large number of them are only multiplications of the same species under the same name, an evil far too common in palæontological works. The genus commences in the Silurian with twelve diminutive species, six of which (referred by Mr. Hall to the genera Edmondia and Cardiomorpha), are from the Trenton limestone of North America, and six from the Silurian strata of England, Sweden, and Germany. By a singular phenomenon, not often repeated, the genus suddenly expands in the Devonian into seventy-nine species, or, including two or three species common to the Silurian and Devonian, into eighty-one or eighty-two. Many of these species appear to be very local, and though forty-eight species have been discovered in the Devonian district, which extends into the Rhenish provinces, into Bavaria, Westphalia, and Saxony, few of them have any lateral extension. Of exceptions, M. Deshayes cites *C. semistriatum* (Goldfuss) common to Bavaria and Northern Russia, and *C. glabrum*, extending from Bavaria to Bohemia, whilst *C. clathratum* is as yet peculiar to the Asturias.

Four Devonian species are repeated in the Carboniferous strata, and twenty other species, bring the total number to twenty-four. One of the most remarkable species is the *Cardium Hibernicum* of Sowerby, which exhibits so abnormal an external form as to have led to the formation of the genus Conocardium by Munster, the genus Pleurorynchus by Phillips; and to this peculiar form belong no less than ten species, including the *Cardium Uralicum* of De Verneuil, which is peculiar to Russia, and the Irish species, *C. inflatum* and *C. eduliforme*, described by M'Coy. After the Carboniferous epoch, this genus, which had yielded one hundred and eleven species, almost disappears, not one having as yet been recorded in the Zechstein, and only one in the Trias (Muschelkalk). In the Oolitic series of formations, the genus becomes again developed; in the Lias, nine species have been discovered, one of which, the *Cardium multicostatum* of Phillips, requires a new name, as Brocchi had previously appropriated that name to a Tertiary species,

and that of *sub-multicostatum*, given by D'Orbigny, appears to M. Deshayes objectionable. In the lower Oolite five species have been found, one of which, *C. cognatum* (Phillips), is common to England and Germany; and another, the *C. citrinoideum* (Phill.), after appearing in England in one bed, re-appears in France in another more elevated in the series. From the great Oolite twelve species have been obtained, and from the Oxfordian section six; of which the *C. concinnum* of De Buch has been found in Russia, England, Scotland, and France. The Coral Rag has yielded nine species, including two, *C. cyreniforme* of Buvignier, and *C. intextum* of Munster, which came up to it from the subjacent section. The upper Oolite has produced only one; and the Kimmeridge of the Meuse several. Here again, another series of more than forty species disappears, but in the Cretaceous formation the genus becomes again fully developed; the lower Greensand yielding twelve species; the Gault four, including one which comes up from the lower Greensand; the upper Greensand twelve; and the Chalk more than thirty.

From the lower Tertiaries thirty-two species of Cardium have been described; probably a far larger number lived in the Miocene epoch, though as yet the confusion in its fauna renders it difficult to determine them with precision; and from the upper Tertiaries have proceeded thirty species. It is impossible in this abstract to give any idea of the critical acumen with which this able naturalist examines and corrects the labours of preceding and contemporary writers, and of the vast number of corrections in nomenclature which he proposes, on apparently sound data. In one great point he is opposed to M. D'Orbigny, as he maintains the passage of some species from one member or section of a formation, and therefore controverts the theory of D'Orbigny as advanced in his Palæontologie of the French Cretaceous Formations,—that each section is distinguished by its own peculiar fauna. However disposed most geologists were some years ago to accede to D'Orbigny's theory, which is indeed only a revival of that of earlier days, the tendency at present is certainly towards the adoption of the modified theory of Deshayes. I have dwelt thus long on this most important portion of M. Deshayes, both because I feel rejoiced at seeing so able a zoologist again engaged upon the difficult task of comparative palæontology, and because the consideration of this family of shells, the Cardiaceæ, is full of interest. From their habits they are principally shore

shells, and as some of them are even fond of brackish, or almost fresh water, they bring us as it were up to the dry land. The remarkable fact, also, that the shells of the earlier species were not provided with teeth seems to connect them more closely with freshwater shells, and to open out to us a view of a former condition of the earth, in which fresh-water seas were at least not wanting. The present course of geological investigation is certainly directed to the discovery of more evidences of land and fresh-water, than were formerly thought probable, and it is therefore interesting to find even these slight indications from analogy of such conditions. I will add here a reference to what has always appeared to me a proof of the existence of dry land, were it now necessary to maintain its existence by argument, at all geological epochs; and that is, the formation of beds of limestone. So far as existing analogies assist us, the course of nature has been to act by atmospheric agencies on the exposed rocks, to decompose them, and then to transfer in solution the carbonate of lime from the land to the sea. Such is the course of nature, as she can be studied in the existing creation, and I cannot doubt that in every past age of the world the brook and river were, as now, the agents by which mineral matter was conveyed from the dry land to the sea; and I am forced therefore to look upon our present ocean as the result of long-continued actions of this kind. I have felt that I could not, under the circumstances I have previously detailed, go further into the work of M. Deshayes, and follow him into the families, Camacea, Cardita, &c.; nor can I do more than briefly allude to the last published portion of the great work of M. D'Orbigny, which contains an investigation of the Escharidæ of the Chalk, and also of the species of the family Flustrellaridæ and the importance of which may be judged by the fact, that M. D'Orbigny describes no less than fifty-four species of the one genus, Biflustra, from the several stages of the Chalk of France; and he thus observes:—"I have united the region of the Loire to the Anglo-Parisian chalk basin, and when thus united they have, in common with the Pyrenean basin, eleven species—a number so great as to prove the contemporaneity of the two basins (the Pyrenean and the Anglo-Parisian)." If viewed geographically, and without reference to the repetition of the species, the following is the development of this genus in the Senonian stage of D'Orbigny:—Neighbourhood of Paris, six species; the channel district, nine species; the region of the Loire,

nineteen species; and in the Pyrenean basin of Saintonge, twenty-three species;—or, uniting them into basins, the numbers are—for the Anglo-Parisian basin, thirty-four; and for the Pyrenean basin, twenty-three species,—a curious illustration of the contemporaneity of these two ancient seas.

In the 184th livraison of his work M. D'Orbigny commences his description of the Bryozoaria; and though we cannot follow him in this part of his subject, the value of his researches may be judged from his statement, that the Chalk formation of France alone has yielded more than 870 species. Nor will I attempt to analyze the recent parts of his "Paleontologie" of the Oolitic system of France, which are devoted to the description of numerous species of Gasteropoda, as it is sufficient for my purpose to state, that whether our consideration be given to animals of a comparatively high organization, or to those of the lower standard of Bryozoaria, the peculiarities and the individuality of each ancient stage of the world's history is fully maintained; not, it is true, with that rigidity of outline which does not admit the passage from one to another stage of even a single species, but with all the essential features so strongly marked as not to admit of hesitation in determining the identity of each.

I shall, therefore, now close my remarks by dwelling very briefly on some remarkable facts, of a still more striking character, which the researches of the past year have brought before the public. For a long time, as you are aware, it was supposed that reptiles first appeared on the earth at the Triasic epoch, the footprints discovered on beds of the new red sandstone having been referred by Professor Owen to his genus Labyrinthodon; but subsequently the class has been carried back to the Carboniferous in the genera Archegosaurus and Apateon; and as the former exhibits, as it were, two types of structure, the Saurian and Batrachian, blended together, we may assume, that at this stage commenced that great development of the class of reptiles which seems to indicate that for a long series of creations, reptiles performed the functions which are now, in a more balanced system, allocated to animals of several distinct classes. In the old red sandstone of Elgin, in Scotland, a reptile has still more recently been discovered, the *Telerpeton Elginense* of Dr. Mantell, in which there are also indications of the simultaneous development of these two types, the Saurian and Batrachian; and Sir Charles Lyell has reminded geologists that the footprints of a fresh-water

tortoise had been previously discovered by Mr. Logan and the Canadian geologists in the Silurian strata of Canada, thus carrying the class back to the very dawn of known animal life. But it is still more curious to find the higher class of Mammals also retreating in their origin to more remote epochs. In 1847, M. Jäger published a most valuable paper in the Transactions of the Society of Naturalists of Bonn, in which he describes numerous Mammals from the Tertiary strata, and two from the Breccia which lies between the Lias and the Keuper. One of these, the *Microlestes antiquus* of Plionenger, seems to belong to the Marsupial type; whilst it is yet doubtful whether the other, *Sargodon tomiens*, is really a Mammal, as M. Jäger expresses a doubt whether it may not belong to the genus Capitodus of Munster, described as a fish in his description of the fossils of the Vienna Basin. This early appearance of the Marsupial type, now almost isolated in Australia, and its recurrence at the Oolitic epoch, are facts of the highest philosophic interest, more especially when it is remembered that there is a similar resemblance in the ancient Flora to that of Australia. It is evident, indeed, from the study of successive creations, that certain forms were more peculiarly developed at certain definite epochs; for example, the Trilobites of Crustacea, and the Nautilidæ, of Cephalopoda, at the Silurian; the class of Reptilia at the Oolitic; the family of Ammonitidæ, of the Cephalopoda at the Cretaceous; the Pachydermata, of Mammals in the early Tertiaries; whilst in the present creation all these types seem properly restricted, and the whole blended into a balanced system, as if prepared for the final and greatest terrestrial work of creative power and wisdom,—Man. It is thus, therefore, that we are justified in saying, that whilst one geological age may be called the age of fishes, another that of reptiles, this is peculiarly the age of Man. In studying it we are applying powers which were denied to other animals, and, although humbly using an intelligence which partakes of the essence of Divinity, we may freely, but reverentially, unfold the mysteries of creation, as they are exhibited in the book of eternal nature, and learn, at least, from the contemplation, that great as Man confessedly is when compared with the irrational creatures associated with him in this world, he is as a mere nothing when compared with the Divine Creator of all things.

November 10, 1852.—"Limestone Boulders of Corkaguiny, County of Kerry."

THE following letter to the Secretary, from the Rev. A. B. ROWAN, was read:—

"BELMONT, TRALEE, *October* 22, 1852.

"SIR,—Some months since, walking with a friend on the borders of a small rivulet (occasionally a torrent when swollen by rains), in a mountain glen in the barony of Corkaguiny, county of Kerry, I saw, lying in the bed of the stream, a remarkable mass of rock, quite different in shape and colour from the boulders of conglomerate and sandstone around it. I immediately said, 'That is limestone.' My friend, one of the best practical farmers in the district, and fully alive to the value of limestone manure, smiled, and said, 'A block of limestone of that size would be a valuable article here.' We descended into the stream, examined, broke off a fragment, and ascertained beyond doubt, that the rock, measuring nine feet by four superficially, and containing many tons of solid content, was crystalline limestone of a pure and compact quality.

"In order to show the peculiarity of the facts I am about to notice, I must describe our position by referring to the 'Outline of the Geology of Kerry,' furnished by Mr. Hamilton, in volume i. pp. 276–285, of the Journal of the Geological Society. We were standing in the valley which he describes as running from Ballygobbin (Kilgobbin) to Castlemain, under the west end of the great sandstone range of Cahirconree, and facing that mountain as it terminates abruptly in a steep face of about 2700 feet elevation. The water-course in which this block of limestone lay flows eastward from that great Corkaguiny range which, as Mr. Hamilton states, is 'composed chiefly of a "coarse siliceous conglomerate,"' but through which, seams of clay and red roofing-slate are occasionally intermixed. *There is not the least vestige of limestone anywhere to the westward* in the whole peninsula of Corkaguiny; and the valley in which we stood is at an elevation of about 600 feet from the sea-beach at Kilgobbin, where, at about two miles distant to the northward, the limestone of the Tralee basin, which dips at the point of Annagh, about six miles to the eastward, again crops up, and shows itself below high-water mark on the shore.

"After this mass was found, my workmen frequently pressed me to consign it to 'the kiln,' and 'murmured at the waste' of

leaving it in its rocky bed, while the material for lime-burning was drawn from a considerable distance. But as I regard the geological curiosity of its position far beyond any value it could obtain as a manure, I have given strict directions that it shall not be disturbed, in the hope that some geologist of larger knowledge than myself may think it worth examination, with a view to working out the problem, '*How came it here.*'

"A few days since, having a leisure hour to spend among the mountains, it occurred to me, that possibly more of these limestone blocks might be found in the same mountain stream; and, hammer in hand, I set out to explore, making my way upwards over the masses of conglomerate with which the bed of the stream is filled. I was not disappointed. I presently found another limestone boulder, and another, and then another; they were generally of small size; though some, imbedded in the gravel, may be of greater dimensions than I have yet ascertained; and I found only one approaching the dimensions of the first discovered mass. At length, having reckoned about a dozen of these erratic blocks, I came to a scaur or bank of earth overhanging the ravine, about ten or twelve feet, which I conjecture to be the nidus from which, *at their last remove*, these blocks have at intervals fallen into the stream below, and been carried down to different distances by the force of the torrent. A number of round blocks of sandstone and conglomerate protruded from the face of this bank, and among them one or two of limestone, which I have not yet disturbed; I examined the stream some way further up, but discovered no limestone beyond this point. All the limestones I found showed fossils, and, with the exception of the first, presented the usual appearance of water-borne stones, round and smooth; the largest block is of a different shape from the rest, being a parallelogram, with rough edges, much honey-combed on the surface, and having one or two deeper cavities such as I have seen elsewhere in limestone formations caused by a sand or other hard stone, lying on the surface, and under the action of the waves working for itself a bed in the depth of the stone, more or less deep as the action of the water is more or less violent.

"The two larger blocks are marked by distinct, well-defined bands of *chert* standing out from the surface of the stone, as resisting the action of the elements, under which the softer limestone yields and wears. I present these facts for the consideration of

scientific geologists, in order that they may speculate, and, if possible, decide, by what agency these masses have been transported from their native bed *upwards* into a mountain glen lying two miles distant *from*, and *at least six hundred feet above*, the nearest limestone formation in the district. No 'glacier theory' can help us in this difficulty, for I believe all transport of 'moraines' and other foreign substances by glaciers is from *above downwards*—and not, as in the present instance, in a direction contrary to that of gravitation.

"Perhaps it may help investigation, if I observe, that I think I have observed, on the face of the opposite mountain of Cahirconree, three distinct horizontal bands at different elevations, for the origin of which I can offer no reasonable conjecture, except that they *may* belong to the phenomena of ancient 'sea-beaches,' of which so many traces are now reported from different parts of the world; the mountain side is too steep to show any signs of 'detritus' or other remains of a sea-beach; but to the eye observing them from below, they present all the appearance of tidal lines scored on the side of the rock at different elevations. I cannot pretend to do more than present these facts for investigation, and to offer any geologist who may think them worth looking after any aid in my power in his further researches.

"I am your obedient servant,

"A. B. Rowan."

"Account of the Gangue of Conlig Lead Mine, County of Down;" by the Rev. Samuel Haughton, Professor of Geology in Trinity College, Dublin.

During a recent visit to Conlig lead mine Mr. Haughton's attention was attracted by the peculiar appearance of the gangue of the lode, particularly by the asbestiform streaked appearance of the dark green crystals forming the walls of the lode. This mine has been very rich in galena for some time past, and was formerly very productive, but from about the 60 fath. level to the 90 fath. was comparatively unproductive. The gangue of the lode presents the same appearance from the surface to 120 fath. deep; it crumbles when exposed to the action of the air; is full of joint surfaces, which are coated with a mineral of the same chemical composition as the gangue itself, crystallized in an asbestiform manner, as shown by the accompanying specimens. The specific gravity of the gangue is 2.721; it fluxes

readily before the blow-pipe into a black slag, and behaves in general as an ordinary trap rock.

Mr. Haughton gave the two following analyses, made by himself and the Rev. Joseph A. Galbraith, from different specimens of the gangue. In both analyses the mineral was fluxed with carbonate of soda and potash, as it was found not to be completely decomposed by strong muriatic acid:

No. I.

	Grains.	Per Cent.	Atoms.	
Weight	= 25.86	100		
$Si\,O_3$	= 11.85	48.88	0.969	1.256 ($Si\,O_3$, $Al_2\,O_3$)
$Al_2\,O_3$	= 3.82	14.77	0.287	
Fe O	= . . .	12.98	0.360	1.255 (Fe O to Mg O)
$(Fe_2\,O_3)$	= 3.73			
Ca O	= 2.64	10.19	0.364	
Mg O	= 2.81	10.88	0.531	
H O	= . . .	8.00	0.888	
		100.70		

This analysis may be well represented by the rational formula:

$$3\,[(Fe\,O,\,Ca\,O,\,Mg\,O),\,(Si\,O_3,\,Al_2\,O_3)] + 2\,H\,O$$

No. II.

	Grains.	Per Cent.	Atoms.	
Weight	30.00	100		
$Si\,O_3$	13.13	43.76	0.966	1.194 ($Si\,O_3$, $Al_2\,O_3$)
$Al_2\,O_3$	3.52	11.73	0.228	
Fe O	. . .	14.34	0.398	1.258 (Fe O to Mg O)
$(Fe_2\,O_3)$	4.33			
Ca O	2.716	9.05	0.323	
Mg O	3.225	10.75	0.537	
H O	2.40	8.00	0.888	
	29.82	97.63		

This gives the same rational formula as before. The mineral has, therefore, the composition of an hydrated aluminous hornblende.

Besides the constituents given above, a small quantity of chrome iron was found present in both specimens.

The Conlig lead mine is the only instance which has come under Mr. Haughton's observation of a pure hornblende constituting the gangue of a lead mine.

December 8, 1852.—"Notice respecting a Variety of Magnetic Iron Ore from Rynvile, near the Killeries, County of Galway;" by JAMES APJOHN, M. D., Professor of Chemistry and Mineralogy, Trinity College, Dublin.

THIS mineral, a specimen of which I obtained from Ethelstan Blake, Esq., of Rynvile, is massive, its recent fracture being of a dark colour, and exhibiting frequently the facets of minute octohedral crystals. It abounds in joints, according to which it generally splits when struck with a hammer, and whose surfaces are usually reddish brown from the presence of the hydrated peroxide of iron. Numerous thin laminæ of a schistose serpentine intersect this mineral, and it has usually attached to it small particles of iron pyrites. Its specific gravity is 3.3953, and it acts powerfully on the magnet.

Submitted to analysis it gave the following results:

Silex,	46.89
Alumina,	2.71
Peroxide of Iron,	39.04
Magnesia,	6.00
Water,	8.70
	103.34

With a view to this analysis the ore was first fluxed, for without this preliminary step its perfect disintegration by acids cannot be effected. Muriatic acid, however, takes up from it much iron, and the solution is precipitated by the ferro and ferrid-cyanide of potassium, so that it must include the two oxides of iron.

This mineral is obviously a massive magnetic iron ore, as is proved by the action of the magnet on it, by the iron being partially present as protoxide, and by the excess in the analysis, which arises from the entire of the iron being estimated in the form of peroxide.

As respects its commercial value, this will best appear by comparing the quantity of iron in it with that occurring in several varieties of clay ironstone.

	Per Centage of Iron.
Mineral from Rynvile,	27.32
Average of 10 Specimens of Scotch and Welsh Clay Ironstone,	31.55
Blue Flat of Staffordshire,	28.19

The amount of metal, therefore, in the Rynvile ore is *quam proxime* the same as that occurring in the variety of clay ironstone principally employed in Staffordshire, and not materially less than

the average of the richer ores of Wales and Scotland. It must, however, be admitted, that it is inferior to these ironstones in one important particular, viz., in containing a considerably larger amount of siliceous clay or gangue. It does, therefore, certainly not follow that, even though the necessary fuel were at hand, it could be smelted with the same facility, or that it would yield the same amount of profit.

In connexion with the economical question just adverted to, I may mention, that the magnesia which appears amongst the results of my analysis may probably be derived from the plates of serpentine which are interspersed through the ore, and which admit by careful manipulation of being separated from it. Assuming it to proceed from such a source, as the magnesia of serpentine constitutes on an average 40 per cent. of it, the magnesia of the mineral under consideration will correspond to 15 per cent. of serpentine; from which it is easy to calculate that 100 parts of the Rynvile ore, if carefully picked, would yield 32.14 of metallic iron,—a proportion much beyond the average of the clay ironstones smelted with profit in many parts of England and Scotland.

Not having been at Rynvile myself, I cannot speak with confidence of the geological position of the ore of iron. As well, however, as I recollect the verbal statement of Mr. Blake, it occurs associated with a vein of serpentine which traverses the mica slate of the district.

January 12, 1853.—"On an Analysis of Euclase;" by J. W. Mallet, Ph. D.

Euclase, from its transparency, delicate shades of colour, and perfect crystallization, is one of the most beautiful mineral species with which we are acquainted, and since it is at the same time a mineral of great rarity, good specimens of it form some of the most highly prized ornaments of mineralogical collections.

Such of the characters of the mineral as can be examined without injury to the specimens have been pretty accurately studied, especially the complex crystalline forms under which it occurs, which have been described at length by Hauy, Weiss, Phillips, and Levy. Our knowledge of its chemical composition, however, the investigation of which involves the destruction of the specimens operated on, depends upon a single analysis by Berzelius, as the numbers given by Vauquelin, the only other chemist who has ex-

amined the substance, are almost valueless, presenting a loss of about 30 per cent.

Though from the high authority of Berzelius as an analyst, any other investigation could scarcely be expected to yield results of much novelty, or differing materially from those he has given, yet a second analysis possesses some interest, even if merely confirmatory of his. The results of one which I have recently made, I wish, therefore, to bring under the notice of the Society.

The material employed for this analysis consisted of four fragments of crystals, weighing together about 20 grains. Though this is rather a smaller quantity than is usually taken for a mineral analysis, it was in the present case quite enough, as the constituents to be determined were but few, and alumina and glucina form a large proportion of the whole. These fragments were perfectly clear and transparent, three of them of a beautiful pale mountain-green colour, and one of a very light tinge of blue. They presented both natural crystal planes and faces of cleavage, and amongst the former were several adapted to the use of the reflecting goniometer. The mean results of some angular measurements over the obtuse lateral edges of four distinct vertical prisms were 115° 6′, 127° 51′, 140° 44′, and 149° 32′, all of which agree nearly with numbers given by Phillips. The only cleavage I observed was that parallel to the terminal plane replacing the acute lateral edge of the vertical prism, which is mentioned in mineralogical systems as the only cleavage easily obtained.

The specific gravity of these fragments was 3.036.

They were reduced to fine powder, and fused with the mixed carbonates of potash and soda, and the analysis was then conducted according to the usual routine for silicates. The alumina and glucina were separated according to the old method by carbonate of ammonia, as from previous experiments I found the use of caustic potash, which has been more recently proposed for this purpose, both difficult and uncertain. The analysis gave the following constituents per cent.:—

		Atoms.
Silica,	44.18	.950
Alumina,	31.87	.620
Glucina	21.43	.564
Peroxide Iron,	1.31	.016
Peroxide Tin,	.35	
	99.14	

These numbers agree very fairly with those of Berzelius, and, dividing by the atomic weights of the several constituents, give their equivalent proportions as in the second column. These are very nearly in the ratio

$$Si\,O_3 : Al_2\,O_3 : G_2\,O_3 = 3 : 2 : 2,$$

and hence we have the formula

$$2\,(Al_2\,O_3,\ Si\,O_3) + 2\,G_2\,O_3,\ \ Si\,O_3,$$

or if the two earths, alumina and glucina, be isomorphous,

$$4\,(Al_2\,O_3 + G_2\,O_3),\ 3\,Si\,O_3.$$

Scacchi, taking glucina as a protoxide, suggests an analogy between euclase and epidote, but if the corrected atomic weight of this earth be used, the formulæ of the two minerals differ widely.* If, on the other hand, alumina and glucina be isomorphous, the composition of euclase coincides with that of andalusite—

$$4\,Al_2\,O_3,\ 3\,Si\,O_3,$$

part of the alumina being replaced by glucina. An important objection to the idea of any real connexion between these minerals, however, arises from the fact, that they occur in different crystalline systems, andalusite belonging to the right prismatic, while euclase is in the oblique prismatic system.

There was one minor point in connexion with Berzelius' analysis which it was interesting to examine with special care, namely, the occurrence or not of a small quantity of tin in euclase, and I, therefore, took particular pains in testing all the re-agents for this metal before using them, and made a separate blow-pipe experiment on the mineral itself, with the object of reducing the tin directly. Even by the latter method there was no difficulty in distinctly ascertaining its presence, and there can, therefore, be no doubt of its really existing in the pure mineral.

The occurrence of traces of this metal in other silicates, as beryl, epidote, and a manganesian garnet, in meteoric stones, and in several ores of titanium and tantalum, has been remarked by different analysts, especially by Berzelius, and is certainly a very curious fact, when we consider the extremely small number of minerals in which tin forms a leading constituent, and the improbability of such minute quantities being essential to the composition of the species in which they occur.

* The angles of crystals of the two species also differ considerably.

"Notes on the Geology of the Southern Portion of the County of Cork;" by W. L. Willson, Esq., of the Geological Survey.

Mr. Willson exhibited the maps and rough sections of the Geological Survey of the southern part of the county of Cork. He commenced by stating that he meant briefly to lay before the Society a few of the results of his observations made in the field during the progress of the Geological Survey, with regard to the thickness, by measurement, of the rocks which intervene between the old red sandstone and carboniferous limestone at different points in the south and south-eastern part of the county. He then briefly alluded to a paper which had been read before the Society in March last, by Mr. J. B. Jukes, Director of the Survey, and called, "A Sketch of the Geology of the County of Waterford." In speaking of the Devonian rocks north of Dungarvan, Mr. Jukes remarks, "that the upper beds, or those which intervene between the old red sandstone and carboniferous limestone, were chiefly composed of sandstones; but near the top, beds of shales occur either red, yellow, or gray, and sometimes dark gray, the thickness of which he estimated at 700 feet. Mr. Jukes then goes on to say:—"But as we trace these beds towards the west, namely, from Dungarvan to Lismore, or from Ardmore to Youghal, we find the sandstones to diminish both in thickness and number, and the intervening shales to increase, especially in the upper part of the group." Mr. Willson then called attention to a small section which exhibited the thickness of this group of rocks, lying between the old red sandstone and carboniferous limestone on the northern coast of Ballycotton Bay, situated nine miles south of Youghal, and about twenty-five miles south-west of the point north of Dungarvan, which Mr. Jukes referred to in his paper. Commencing with certain beds of red slates and sandstones shown in section as the upper portion of the old red sandstone, and ascending, the following rocks occur:—1st, 500 feet of red and green shales and slates, with a few sandstones; 2ndly, 600 feet of greenish, gray, and brown grits, and yellowish-white flagstones, separated by bands of gray shale; and, 3rdly, 900 feet of gray and bluish-gray shales and slates, with a few grit beds occuring at intervals, on top of which apparently rests the carboniferous limestone, which is here very crystalline, and of a pale gray colour; the bluish-gray slates immediately beneath the limestone are, in places, calcareous;

thus there is a total thickness here of 2000 feet between the old red sandstone and the carboniferous limestone. Tracing these beds in a westerly direction, the strike being nearly east and west, they are found to form an unbroken line, passing close to the village of Cloyne, and from thence along the northern side of Cork Harbour to Queenstown, and so on, crossing the Cork river a little west of the latter place, to Monkstown on the opposite side, situated eighteen miles to the west of Ballycotton. South of the village of Monkstown another section of this group of rocks is seen: they are very much the same in the lower beds as at Ballycotton, but in the upper portion, consisting of bluish-gray slates, very similar to those on which the limestone seemed to rest at Ballycotton Bay; they are considerably thicker, about 600 feet, making a total thickness here of 2600 feet between the old red sand and the limestone. Tracing these beds again in a westerly direction, they are found to continue, forming a well-defined ridge of high ground to Ballinhassig, and from thence passing by Five-mile-bridge; and so on in the same strike to the north of Bandon, when the strike begins to change more to the south, and the beds arise in that direction, forming the northern boundary to the comparatively level plain which extends from Bandon to Dunmanway. In tracing these beds from Monkstown towards Bandon they are found to gradually increase in thickness, and also in extent, until at Ballinhassig they spread out, covering the large undulating tract of country lying between the latter village and Kinsale, bounded on the north by the high ridge of ground formed of the old red sandstone which extends from Monkstown in the east to Dunmanway in the west, and on the south by the sea and the headlands called the Old Head of Kinsale, and the Seven Heads, in the latter of which we find the old red sandstone re-appearing again, dipping to the north at a high angle. Mr. Willson then described a section which was drawn across this large tract of country, formed of these rocks which intervene between the old red sandstone and the carboniferous limestone. It commenced at a point four miles north of Bandon, and ended at the southern point of the Seven Heads, passing close to the town of Bandon, and the village of Courtmacsherry. Commencing at the point four miles north of Bandon, which is in the same line of strike as the Ballycotton and Monkstown sections, and taking certain beds of red sandstones and slates, shown in section to represent the upper beds of the old red sandstone, and

ascending in the section, the following thickness of rocks is observed, viz. 500 feet of dark purple and green slates, with green and dark-brown sandstones; 1500 feet of greenish-gray grits; yellowish-white flagstones, alternating with thick bands of greenish-gray shales; and 1800 feet of dark-gray and bluish-gray shales, often cleaned into fine slates, and worked for roofing purposes; with bands of gray grits occuring at intervals to the top of the group: making a total thickness here of 3800 feet, without coming to any limestone as at Ballycotton and Monkstown. These rocks, as shown in section, undulate and roll to the south, gradually attaining a greater thickness in that direction. Commencing now at the southern end of the section, viz. at the Seven Heads, where the old red sandstone re-appears with a reverse dip to that which it has at the northern end of the section; and taking certain beds of red slates, &c., to represent the same beds of the old red sandstone as those seen at the northern end of the section, and ascending in this section, the following thickness occurs:—1stly, 500 feet of dark purple and green slates, with green sandstones; 2000 feet of greenish-gray grits, and yellowish-white flagstones, separated by bands of gray shale and slates; and, finally, 2000 feet of dark-gray and bluish-gray shales and slates, with grit bands through them, occurring at intervals to the top, near to which the shales are often dark, almost black, soft, earthy, and calcareous;—making a total thickness here of 4500 feet of this group of rocks without coming to any limestone on top, so that there is no certainty that the uppermost beds of this series have been reached here. Commencing at Ballycotton Bay, situated thirty-five miles to the west of the Seven Heads, where the thickness was seen to be 2000 feet; and proceeding in a westerly direction along the same beds, we find a gradual increase taking place in the upper portion of the group, as at Monkstown, eighteen miles west from Ballycotton, there was a gain of 600 feet. Again, four miles north of Bandon, and thirty-five miles west of Ballycotton, there was a gain of 1800 feet, and from that point to the Seven Heads, about sixteen miles in a southerly direction, there was a further gain of 700 feet between these two north and south points, showing an increase in thickness of this group of rocks between Ballycotton Bay and Courtmacsherry Bay (or the Seven Heads section) of 2500 feet, and which must be taken as merely approximative to the upper beds at the latter place, from the absence of any limestone. In

conclusion, Mr. Willson begged to notice what at present seemed a curious fact regarding the great thickness of these rocks here, and the absence of limestone; namely, that at Macroom, about twelve miles north-east of the point north of Bandon, where this section was drawn from, limestone is seen to occur, and seems to rest upon a very thin band of the lower portion of this group of rocks,—viz. gray and greenish-gray grits, and yellowish sandstones. The greater part of these rocks (seen here to be 3800 feet thick) seems to be wanting at Macroom.

AT THE

ANNUAL GENERAL MEETING

HELD ON

WEDNESDAY, FEBRUARY 9th, 1853,

THE PRESIDENT,—ROBERT BALL, L.L.D.,

IN THE CHAIR,

The following Report from the Council was read and adopted:

THE Council have to offer to the Society the following Report for the past year.

During the past year fourteen new Members have been added to the Society, viz.:—Right Hon. the Chief Baron (rejoined); Rev. Richard Mac Donnell, D. D., Provost of Trinity College (rejoined); John Hamilton, Esq.; Gilbert Sanders, Esq.; John B. Doyle, Esq.; John J. S. Moore, Esq.; Samuel Gordon, M. D.; Robert Smith, M. D.; Richard Wolseley, Esq.; John Wallace, Esq.; William Clarke, Esq.; John England, Esq.; William Scott, Esq.; and George Henry Kinahan, Esq. (formerly an Associate).

The following Associate Members have also joined during the same period, viz.:—J. Pigot, Esq.; John W. Mallet, Esq.; William Smith, Esq.; Charles P. Cotton, Esq.; Thomas M'Comas, Esq.; Arthur Jacob, Jun., Esq.; Joseph Kincaid, Jun., Esq.; and John Haughton, Esq.

The Society has lost during the year, from death, and other causes, twelve Members, viz.:—Joseph G. Medlicott, Esq; George Wilkinson, Esq.; B. Mullins, Esq.; W. J. Collett, Esq.; William Fraser, Esq.; M. B. Mullins, Esq.; Colonel Bruen, M.P; Sir William Homan, Bart.; Thomas Brien, Esq.; Sir Philip Crampton, Bart.; Leland Crosthwaite, Esq.; and Sir John Macneill.

The present state of the Society as to numbers is as follows: 4 Honorary Members, 35 Life Members, 87 Annual Members, and 16 Associate Members; total amounting to 142 Members.

The Council refer with satisfaction to the increase in the class of Associate Members, as it is to this class that they look as likely in a few years to constitute a kind of reserve fund for the supply of active and practical workers in the field, and thus restore to the Geological Society of Dublin somewhat of the activity and zeal of its early days.

The financial difficulties to which the Council were obliged to refer at the last Annual Meeting have nearly disappeared, and, as will be observed by the accompanying balance sheet, the balance has been transferred to the proper side of the account.

This balance is, however, small, amounting to £2 11*s.* 5¼*d.* In addition to this balance, the Society has standing to its credit in the public funds the sum of £95 5*s.* 3*d.*

The Council have carried out their intention of paying old bills before incurring fresh liabilities, and they are in a position to report that there is not a single outstanding account against the Society.

During the year the Second Part of Vol. V. of the Journal of the Society has been published, and the Third Part of the same volume is in progress, and will be issued to the Members during the summer.

The following List contains an account of the Donations made to the Society during the year.

DONATIONS

RECEIVED SINCE LAST ANNIVERSARY.

1852.

March 3.—Proceedings of the Liverpool Literary and Philosophical Society, No. 6. Presented by the Society.

March 3.—Returns of Agricultural Produce in Ireland, in the year 1850. Presented by the Commissioners.

March 10.—Quarterly Journal of the Geological Society of London, No. 29. Presented by the Society.

March 10.—Museum of Practical Geology.—Government School of Mines and of Science applied to the Arts.—On the Importance of special Scientific knowledge to the Practical Metallurgist, by John Percy. On the Science of Geology and its Applications, by Andrew C. Ramsay; and, On the Value of an extended knowledge of Mineralogy and the Processes of Mining, by Warington W. Smyth. The whole presented by Sir Henry T. De la Beche.

March 15.—Transactions of the Royal Scottish Society of Arts, Vol. III., Part 5. Presented by the Society.

March 17.—Institution of Civil Engineers.—Minutes of Proceedings, 1849–51; with a List of Members of the Institution, December 24th, 1851. Presented by the Institution.

April 7.—A Sketch of the Physical Structure of Australia, by J. Beete Jukes, M.A., F.G.S., &c. Presented by the Author.

April 14.—Two Sections of the Campagna Romana. By M. de Medici Spada, and Professor Ponzi. Presented by Thomas Hutton, Esq.

June 9.—Quarterly Journal of the Geological Society of London, No. 30. Presented by the Society.

June 9.—On the Original and Actual Fluidity of the Earth and Planets, by the Rev. Samuel Haughton, M.A. Presented by the Author.

1852.

June 9.—On the Causes which may have produced Changes in the Earth's Superficial Temperature, by W. Hopkins, Esq., M.A. Presented by the Author.

June 9.—Address delivered at the Anniversary Meeting of the Geological Society of London, on the 20th of February, 1852, by William Hopkins, Esq. Presented by the Author.

Sept. 20.—Athenæum.—Rules and Regulations, List of Members, 1850, and Donations to the Library, 1849; with Addenda for 1851. Also, Annual Report, &c., from 1st January, 1851, to 31st December, 1852. Presented by the Club.

Sept. 20.—Quarterly Journal of the Geological Society of London, No. 31. Presented by the Society.

Sept. 20.—Journal of the Royal Geographical Society of London, Vol. XX., Part 2; Catalogue of the Library, corrected to May, 1851; and an Address at the Anniversary Meeting, 24th May, 1852, by Sir R. I. Murchison, G. C. St. S., &c. Presented by the Society.

Nov. 3.—The Mastodon Giganteus of North America, by John C. Warren, M.D. 4to. Boston: 1852. Presented by the Author.

Nov. 3.—List of Donors to the Dublin University Museum and Herbarium, with a General Statement of their Donations, from May, 1844, to August, 1852 (two copies). Presented by Robert Ball, LL.D., Director of the Museum.

Nov. 3.—Fourth and Fifth Annual Reports of the Board of Regents of the Smithsonian Institution. Programme of Organization; Registry of Periodical Phenomena. List of Works published by the Smithsonian Institution. List of Foreign Institutions in Correspondence with the Smithsonian Institution (two copies). Abstract of the Seventh Census [of the United States]. Directions for Collecting, Preserving, and Transporting Specimens of Natural History. Message from the President of the United States to the two Houses of Congress, at the commencement of the first Session of the Thirty-first Congress, Part III. Report of the

Secretary of War, communicating Information in relation to the Geology and Topography of California. A Notice of the Origin, Progress, and present Condition of the Academy of Natural Sciences of Philadelphia, by W. S. W. Ruschenberger, M. D. (two copies). Map of that part of the Mineral Lands adjacent to Lake Superior, ceded to the United States by the Treaty of 1842 with the Chippewas. The whole presented by the Smithsonian Institution.

Nov. 3.—Sur le Pouvoir Magnétique des roches, par M. A. Delesse; Mémoire sur la constitution Minéralogique et Chimique des roches des Vosges, par M. Delesse. Presented by the Author.

Nov. 5.—Morse's Patent.—Full Exposure of Dr. Chas. T. Jackson's Pretensions to the Invention of the American Electro-magnetic Telegraph, by Hon. Amos Kendall. Presented by the Author.

Nov. 18.—First Biennial Report on the Geology of Alabama, by M. Tuomey. Presented by Henry W. Collier, Esq., Governor of Alabama.

Dec. 1.—Quarterly Journal of the Geological Society of London, No. 32. Presented by the Society.

1853.

Jan. 5.—Italian Irrigation; being a Report on the Agricultural Canals of Piedmont and Lombardy, by R. Baird Smith, F. G. S., &c. 2 vols., and a vol. of Maps and Plans. Presented by the Court of Directors of the East India Company.

Jan. 5.—Transactions of the Royal Scottish Society of Arts, Vol. IV., Part 1. Presented by the Society.

Jan. 5.—The Athenæum, 1852. Presented by the Editor.

Jan. 5.—The Literary Gazette, 1852. Presented by the Editor.

Jan. 5.—The Musical Times, Nos. 73 to 105; with a Catalogue of Music. Presented by the Editor.

Jan. 12.—Journal of the Royal Geographical Society of London, Vol. XXII. (1852). Presented by the Society.

Feb. 2.—Journal of the Society of Arts, Nos. 1 to 11. Presented by the Society.

Feb. 9.—Fossil Plant from the Coal Measures, Tipperary.

ADMISSION FEES.

	£	s.	d.
George M'Dowell, Esq.,	1	0	0
H. Medlicott, Esq.,	1	0	0
Rev. J. H. Jellett,	1	0	0
Rev. A. B. Rowan,	1	0	0
Alexander Jack, Esq.,	1	0	0
John Hamilton, Esq.,	1	0	0
J. B. Doyle, Esq.,	1	0	0
G. Sanders, Esq.,	1	0	0
John J. S. Moore, Esq.,	1	0	0
	£9	0	0

LIFE SUBSCRIPTIONS.

	£	s.	d.
J. Beete Jukes, Esq.,	10	0	0
Sir Henry De la Beche,	5	0	0
	£15	0	0

SUBSCRIPTIONS.

	£	s.	d.
G. M'Dowell, Esq. (1851–52),	2	0	0
H. Medlicott, Esq.,	1	0	0
Lord Talbot de Malahide,	1	0	0
Edward Wright, LL. D.,	1	0	0
Thomas M'Guire, Esq.,	1	0	0
A. M. Giles, Esq.,	1	0	0
H. W. Allen, Esq.,	1	0	0
John Patten, Esq.,	1	0	0
H. Bruce, Esq. (1850–51–52),	3	0	0
R. Barney, Esq., do.	3	0	0
A. M'Mullen, Esq. (1851–52),	2	0	0
Richard Griffith, LL. D. (1850–51–52),	3	0	0
Robert Mallet, Esq.,	1	0	0
E. J. Shirley, Esq. (1851–52),	2	0	0
C. W. Hamilton, Esq. (1850–51–52),	3	0	0
R. Hitchcock, Esq.,	1	0	0
J. Petherick, Esq.,	1	0	0
Dr. Harvey,	1	0	0
Carried forward,	£29	0	0

	£	s.	d.
Brought forward,	29	0	0
Rev. Dr. Lloyd (1851–52),	2	0	0
E. Dawson, Esq.,	1	0	0
W. Dawson, Esq.,	1	0	0
Rev. J. H. Jellett,	1	0	0
W. H. Curran, Esq. (1850–51–52),	3	0	0
M. D'Arcy, Esq.,	1	0	0
Earl of Bective (1851–52),	2	0	0
J. Nicholson, Esq.,	1	0	0
Dr. Duncan,	1	0	0
Thomas Hutton, Esq.,	1	0	0
C. P. Croker, M. D.,	1	0	0
William Edington, Esq.,	1	0	0
W. W. Campbell, Esq. (1851–52),	2	0	0
S. Downing, Esq.,	1	0	0
J. Mollan, M. D. (1851–52),	2	0	0
Robert Ball, LL. D.,	1	0	0
John MacDonnell, M. D.	1	0	0
Carried forward,	£52	0	0

	£	s.	d.
Brought forward,	52	0	0
M. M. O'Grady, M. D. (1850-51), ...	2	0	0
James H. Hamilton, Esq. (1851–52), ...	2	0	0
Earl of Leitrim, ...	2	0	0
Rev. W. A. Willock, . . .	2	0	0
Luke White, Esq., ...	2	0	0
A. Jacob, M. D. (1851), .	1	0	0
J. Apjohn, M.D., ...	1	0	0
Earl Fitzwilliam, ...	1	0	0
Chief Baron Pigot, Composition,	2	0	0
Rev. the Provost, ...	2	0	0
Dr. Allman, ...	1	0	0
Robert Callwell, Esq., . . .	1	0	0
John Wynne, Esq. (1850–51–52), ...	3	0	0
The Archbishop of Dublin, .	2	0	0
Rev. A. B. Rowan (4 years),	4	0	0
W. T. Wilkinson, Esq., . . .	1	0	0
George Yeates, Esq. (1850-51–52), ...	3	0	0
H. H. Head, M. D., . . .	1	0	0
Thomas Hamilton, Esq., . .	1	0	0
G. Wilkinson, Esq. (1851),	1	0	0
Alexander Jack, Esq., . . .	1	0	0
F. M. Jennings, Esq. . . .	1	0	0
F. J. Sidney, LL. D., . . .	1	0	0
Rev. J. Galbraith, ...	1	0	0
Rev. S. Haughton, ...	1	0	0
John Hamilton, Esq., . . .	1	0	0
Carried forward,	£93	0	0

	£	s.	d.
Brought forward,	93	0	0
John Purser, Esq., ...	1	0	0
John B. Doyle, Esq., . . .	1	0	0
G. Sanders, Esq., ...	1	0	0
J. Welland, Esq., ...	1	0	0
P. Byrne, Esq., ...	1	0	0
John J. S. Moore, Esq., . .	1	0	0
Rev. Dr. Wall, ...	1	0	0
F. Codd, Esq. (1851–52), .	2	0	0
Lieut.-Col. Portlock, . . .	1	0	0
J. I. Whitty, Esq., ...	1	0	0
Dr. Harrison, ...	1	0	0
John Radcliffe, Esq., . . .	1	0	0
Rev. Dr. Graves (1851–52),	2	0	0

Associate Members.

	£	s.	d.
W. Thornhill, Esq., . . .	0	5	0
J. Kennedy, Esq., ...	0	5	0
G. Kinahan, Esq., ...	0	5	0
J. Cogan, Esq., ...	0	5	0
J. O'Kelly, Esq., ...	0	5	0
A. MacDonnell, Esq. (1851-52), ...	0	10	0
J. K. Reid, Esq., ...	0	5	0
James Pigot, Esq., ...	0	5	0
J. W. Mallet, Esq., ...	0	5	0
I. O'Mahony, Esq., ...	0	5	0
A. A. Jacob, Esq., ...	0	5	0
W. Smith, Esq., ...	0	5	0
	£111	5	0

ABSTRACT OF THE TREASURER'S ACCOUNT FOR THE YEAR ENDING FEBRUARY, 1853.

Dr.

	£ s. d.	£ s. d.
To Admission Fees, ...		9 0 0
— Life Subscriptions, ...	£15 0 0	
— Annual do.	111 5 0	
		126 5 0
— Half year's Interest to 5th April, 1852, on £80 12*s.* 8*d.*, 3¼ per Cent. Stock, .	1 6 2	
— Do. on £90 10*s.* 9*d.*, to 10th October, .	1 9 5	
		2 15 7
		£138 0 7

Cr.

Date		£ s. d.	£ s. d.
1852.	By balance due to the Treasurer on the last year's Account, ...		26 5 10½
April 7.	—By paid Printer's Account (per Draft 3813), .		25 7 9
„ 22.	—By sundry small expenses, per the ook, . .	£5 1 5	
	— ;	1 10 0	
	— Cost of £9 18*s.* 6*d.*, 3¼ per Cent. Stock, with Interest, &c. . . . (per Draft 3814)	10 0 0	16 11 5
June 16.	—By Mr. W. Oldham's Account for Drawing and Engraving. . .	£5 15 0	
	—Expenses p Book, (	7 4 10	12 19 10
Nov. 3.	—By Assistant from 14th February Draft 3816), .		10 0 0
„ 17.	—By Printer's Account (per Draft 3817), . . .		28 7 4
Dec. 15.	—By do. do. . . .	£3 11 10	
	— Expenses per Assistant Secretary's book, (per Draft 3818),	5 10 7	9 2 5
1853. Jan. 19.	—By Cost of £4 14*s.* 6*d.*, 3¼ per Cent. Stock, with Interest, &c. (per Draft 3819), ...		5 0 0
	— Collector's Poundage, ...		6 15 8
	— By balance in Treasurer's hands, ...		2 11 5½
			£138 0 7

WILLIAM EDINGTON, *Treasurer.*

The following Officers for the ensuing year were then declared duly elected, and the Society adjourned to receive the President's Annual Address:—

President:

JOSEPH BEETE JUKES, M.A.

Vice-Presidents:

HUMPHREY LLOYD, D.D., S.F.T.C.D.
ROBERT BALL, LL.D.
LIEUT.-COL. PORTLOCK, R.E.
ROBERT MALLET, C.E.
JAMES APJOHN, M.D.

Treasurers:

WILLIAM EDINGTON, ESQ.
SAMUEL DOWNING, C.E.

Secretaries:

REV. S. HAUGHTON, F.T.C.D.
FREDERICK J. SIDNEY, LL.D.

Council:

RICHARD GRIFFITH, LL.D.
C. W. HAMILTON, ESQ.
JOHN MACDONNELL, M.D.
PROFESSOR HARRISON, M.D.
THOMAS HUTTON, ESQ.
ROBERT CALLWELL, ESQ.
PROFESSOR HARVEY, M.D.
REV. J. A. GALBRAITH, F.T.C.D.
JOHN KELLY, ESQ.
LORD TALBOT DE MALAHIDE.
PROFESSOR ALLMAN, M.D.
*GEORGE M'DOWELL, ESQ., F.T.C.D.
*REV. PROFESSOR JELLETT, F.T.C.D.
*EDWARD WRIGHT, LL.D.
*GILBERT SANDERS, ESQ.

ANNUAL ADDRESS

DELIVERED BEFORE THE

GEOLOGICAL SOCIETY OF DUBLIN,

FEBRUARY 16, 1853,

BY

ROBERT BALL, LL.D., M.R.I.A., &c., &c.,

PRESIDENT OF THE GEOLOGICAL SOCIETY OF DUBLIN; DIRECTOR OF THE DUBLIN UNIVERSITY MUSEUM;
SECRETARY TO THE ROYAL ZOOLOGICAL SOCIETY OF IRELAND;
PRESIDENT OF THE DUBLIN UNIVERSITY ZOOLOGICAL ASSOCIATION;
LOCAL SECRETARY, RAY SOCIETY; AND SECRETARY TO THE QUEEN'S UNIVERSITY IN IRELAND.

When you did me the very high honour last year of electing me to be your President, I took the Chair with the expressed resolution on my part not to hold it longer, if I could make way for a person more suited for the office by a practical acquaintance with geology, as I consider that, in the present state of the Society, such knowledge is essential to him whose duty it is to guide you in your future progress. For myself, my avocation as a public servant for more than twenty-five years rendered the acquisition of any scientific knowledge difficult, and practical geology, in its special meaning, all but impossible. It is true, that I have read geological works; that I have some knowledge of collateral branches of natural science; and that I have had a very active share in the working of the Society, and have sedulously attended its meetings for seventeen years;—yet I have not had the practical application which, as I before said, I deem essential to your Chairman. It may be supposed that, as I have been placed on the retired list as a public servant, I should now have time to acquire the knowledge to which I refer; but I cannot do so in a year, and I do not purpose attempting it, believing that I can render better service to geology by promoting some of the branches of natural science to which my taste more inclines me; and, paradoxical as it may seem, looking forward to having less time for varied pursuits than I have yet had,

as I may now hope occasionally to engage in works such as the daily duty I was heretofore charged with rendered it idle to attempt.

For the year of my Presidency, and for some time before, I have had very close occupation, I may say without intermission; in consequence, my health gave way some three weeks since. I am still far from well; and have only within the last three days been able to think of an Address.

To follow out the example of my most excellent friend, your late President, Lieutenant-Colonel Portlock, and give not only a critical abstract of the papers that have been before you during the last year, but also an elaborate *resumé* of the progress of geological science throughout the world, calls for an amount of ability, information, and time, which was never at my disposal. But for the illness to which I have referred, I would have attempted a review of the sixteen papers which were last year before you;—I leave it to my talented successor as a debt due by this Chair, and rely on his good nature to clear it off in his next Address, with the view of keeping up the series of information as to our progress, to be found in the several Addresses, a practice by which the value of the various papers is much enhanced.

I have considered it right to say thus much of myself to prevent misconception, and also to plead in extenuation of the Address it is now my duty to make to you, and to deprecate comparison with those of the many able and learned men who have preceded me in this Chair, in which I shall ever consider it an honour to have sat.

Having thus informed you of what I am not going to do, I proceed to make an humble attempt, but I trust not a useless one, for the encouragement of the junior members of the Society, by showing them what they can do, may do, and (may I say?) ought to do. But first I would notice the origin of the Society;—it was founded in 1831, by the exertions of the late eminent and reverend Provost Lloyd, aided by other distinguished men; it was, as it were, an offshoot from the Royal Irish Academy, having the investigation of the mineral structure of the earth, and more particularly of Ireland, for its avowed object, one in which it has displayed a great amount of perseverance and zeal. And here I may remark, that not long since our unfailing friend, the father of our Society, and one of our first Vice-Presidents, Dr. Griffith, stated that he was one of the founders of the London Geolo-

gical Society, and that all the individuals who met together to form that Society were then alive. It is scarcely less remarkable that he, with the first Secretaries, Treasurers, and the fifteen Council of this Society, who were assembled together just twenty-two years since at the Provost's House,—twenty men, not then very young, are all in vigour at the present time, evidencing that geologists—with sound minds (which we cannot doubt)—have singularly sound bodies. To return from this digression to the working of the Society: we have records of 286 papers having been delivered at our meetings. It may well serve the object I have in view to mention them individually (see Appendix); they show the many able minds which have been engaged in promoting our objects, as well as the very varied subjects which have been treated of; yet, were there many times more, materials would not be exhausted (*acquirebat eundo*), one paper produces others, and not unfrequently a great mistake produces excellent information in discussion, and leads to the preparation of careful papers. Be not, therefore, afraid—if you do not teach, you may learn in the best school, i. e. in endeavouring to instruct others and to correct yourselves. Though we cannot hope to excel the zeal, perseverance, and energy of some of the early members of the Society, we may fairly hope to equal them; we have now our science on a better established basis, and each accession to it serves to open up sources not thought of in the former period; we have, therefore, the less excuse if we fail to make progress.

It has been ignorantly said, that the Government Survey has been doing, under our Presidents Portlock, Oldham, and our new President, with their able assistants, all that this Society contemplated. With all respect for the talents of our friends and their aids, they did not, they will not, and they do not pretend to take charge of all the work we cut out for ourselves, and if they did, they could not do it. Doubtless, by them will be laid down the broad and comprehensive chart which will guide the course of future geologists, who, if prudent, will not trust too far. Opportunities daily arise which the Survey cannot have; by these individuals may correct the maps, and step by step improve the great work towards which the indefatigable exertions of Dr. Griffith had made such wonderful approach. I feel quite assured that the officers of the Geological Survey will heartily thank any of our members who, in

a philosophical spirit, may even attempt to point out facts which they may observe in sinkings or cuttings, and which may not have fallen under the notice of the Survey. I thus urge you to measure hammers with this formidable government service, but should you not dare to do so, there is ample room for you to take a wide berth and advance geology in many ways. It is a science embracing so much, that I believe I am correct in saying, that there lives not a perfect geologist armed at all points; such panoply is not for one man; but what one man cannot do, a society may do; we include zoologists, botanists, mineralogists, chemists, meteorologists, geographers, physicists, &c.; the new-coined palæontologist ought to be a zoologist and botanist tolerably perfect, i. e. skilled in a knowledge of organized beings recent and fossil; the latter can only be properly understood by means of the former, while the zoologist and botanist who does not know extinct species is but half made up. The labours of the various members to whom I have referred, being brought into the common stock, will in time come to be combined in a harmonious whole by some master mind. In the early time of geology, crude hypothesis in the closet was the occupation of learned cosmogonists; now, those who work at home use the facts which those occupied in the field accumulate; thus the structures they raise, based on facts, are permanent, while the products of erudite but visionary brains have passed away. I know many think it difficult, if not impossible, to teach generally how to observe. The difficulty will usually be found to exist in preconceived notions in the pupils; I consider that few persons of ordinary intelligence can be found who might not usefully observe. If they will set themselves to carefully describe what they actually see, and no more, they will soon find their powers increase, and learn to be accurate; a facility of making useful deductions is not so easily acquired, but if the young geologist will content himself with perseveringly accumulating facts, without immediately doing so to support any preconceived idea of his own, the true bearing of these facts will, sooner or later, burst upon him. Is there any one amongst us who cannot do something in our service? I think not. Those who are near fossiliferous strata may collect specimens of their organic remains. If merely in the old-fashioned way, it is a pretty and healthful recreation, but for geological purposes the greatest care is necessary to note the locality and the relative numbers of species, their respective posi-

tions in the beds, &c.; even without these scientific additions the general collection of fossils is useful in training the eye of the naturalist to the distinction of species.

Within a short distance of Dublin many palæontological questions remain unanswered; such as the distribution of shells in the carboniferous limestone, their varieties, and the probable causes on which these varieties depended. In the drift a search for arctic shells is well worthy of attention, as is the discovery of shell marls, newer than the glacial drift, but associated with it.

A careful collection of the bones of vertebrate animals, wherever they may occur in bogs, marl, gravel, as indicating remote antiquity, is much urged; it is but a short time since that the former existence of bears in this country was contradicted on historical evidence, supported by the fact that no remains had been found. It is only very lately that we have had unquestionable evidence of very large bears having existed coeval with the giant deer of Ireland, apparently the carnivorous restrainer of the increase of that mighty ruminant. It is but a few years since the remains of rein-deer were found in quantity close to Dublin, yet, doubtless, both bears and rein-deer have left in our marls many of their bones, which, for want of knowledge, have not before attracted attention.

The microscope opens up a fine field of discovery, and I believe one not at all sufficiently worked. The study of the entomostraca, both recent and fossil, is replete with pleasure, and, probably, if fully pursued, would be found to lead to as sound diagnosis in geology on certain points, as the study of the larger fossils. Baird's book, published by the Ray Society, and Jones's, by the Palæontographical, would suffice to point the way to an inquirer in this direction.

As regards the structure of rocks much remains to be done in examining in minute detail the metamorphoses, such as may be found on the flanks of the granitic district of Wicklow:—the subjects of slatey cleavage; of the foliation of various schists; and the difference between cleavage and the separation of crystalline plates. The nature of many igneous rocks has never been explained.

A well-digested arrangement of rocks, founded, probably, on the chemical constitution, is most desirable, and many years of exertion may be well bestowed on it. Its want is felt by the field geologist; it is a stumbling block in the way of the application of economic

geology, and it leads to great confusion in discussions, as we have often witnessed.

It appears to me that electricity in its various forms may be used experimentally to much advantage in aid of geology. Modifications of the electrotype processes may, I expect, afford much help to inquirers in this direction. There is in the University Museum the remains of what was once a miner's pick; the iron is all gone, and in its stead is a mass of native copper; while along the handle, which is still quite sound, are crystallized minerals; the whole affording evidence of active processes still at work, and capable of modifying the distribution of metals in a very remarkable manner.

Members who have opportunities may render our Transactions more valuable by contributing reports of mining operations, and will find much scope for earnest application in metallurgical pursuits. Though these can scarcely be called geological, yet they are so nearly connected as to be quite within our objects, and the history of metallurgy will show that no applications of science are more important than those it requires.

When we reflect that it is probably owing to the exertions of our elder brothers in London, and our own here, that geology has come to be recognised by Government and the public, and that it is now taught in our time-honoured University, in the three provincial Colleges, in the Dublin Society, and, through its operation, in various towns through Ireland, as well as disseminated all over the country by the operation of the Geological Survey,—we may fairly feel proud of the share we have had in such a result, and may look forward with more than hope to the great increase of the Society from the springs of geological knowledge which have been thus opened within a very few years. Our founders would have rejoiced could they have anticipated such a power as I have alluded to, and they would naturally have speculated on great results. Shall we not have them? If not, it will be as discreditable to us as their great advancement, under many difficulties, was honourable to them.

It is right to warn young geologists against the mischievous class of persons called *cui-bono* people, who, though they endeavour to decry inquiry where a useful end is not seen, too often successfully snatch the benefits from those who arrived at them by exercising the highest privilege and most glorious occupation of man,—

the search for truth for its own sake. It is in such search that I look for any great step in geology. Those who inquire, with a definite end in view, may be said to have half discovered it already; while experience shows us that the mighty progress of recent time is the result of the application of truths discovered by philosophic labour, rarely undertaken with any view to such application. I therefore urge the search for truth; every truth found adds to human power; and in geology ascertained facts are the implements necessary for progress.

Besides your scientific exertions in the cause of the Society, there are other aids which you may render, such as inducing suitable persons to join it. If each of you bring in one you will enable the Council to publish more, and will probably do a real service to your friends. You may have perceived, by the Report of the Council, that the progress of the Society has been steady; debts have been cleared off; the numbers of the Society have increased; and, on the whole, a fair promise for the future is given. It remains with you to realize still greater success. Will you work? If you will, gird on your hammers, and to the assault forthwith.

In leaving the Chair I must again express my sense of the high honour I have had to have filled it. I would have gladly complied with the wish that I should have continued to do so if I did not think it my duty to the Society to endeavour, by my retreat, to secure for you the services of my excellent and able friend, Mr. Jukes, Director of the Geological Survey of Ireland. To overcome his scruples was my greatest difficulty; in the which your generous desire to do me honour made me more earnest. It appears to me that the spirit of the law of the Society is, that changes should be made in the Presidentship as often as practicable. Hence the restriction to two years as a maximum; besides, I find two precedents for one year, viz., Colonel Colby, in 1837, and Dr. Griffith, in 1840. The rule, as a general rule, may be a good one, but in my case I felt in myself a want of that special knowledge which you will, I am sure, understand more fully when you find the increased spirit which will necessarily manifest itself from the practical experience of your Chairman, whom I now beg to instal, with hearty good wishes, and a feeling that he will experience from your hands the same courtesy and kindness I have always received, and for which I am most grateful.

March 9, 1853.—"On the Queen's County Collieries;" by Arthur A. Jacob, C. E.

The Leinster coal formation extends over a large tract of country, including portions of the Queen's County and of the counties of Kilkenny, Tipperary, and Carlow. It has been deposited upon and is conformable with the mountain limestone, and overlies the latter to a considerable depth. The entire district is surrounded by flat-topped hills: thus, a basin is formed, to the centre of which the beds uniformly incline. There are, of course, several exceptions, due to local disturbance.

I have selected for this evening's paper the parts situate in the Queen's County. This part is bounded to the north by Cullenagh, to the south by the Kilkenny coal district, to the east by Ballylinan and Ballickmoyler, and to the west by Ballinakill and Ballyroan.

The outcrop of the lower beds of sandstone belonging to the coal measures can be seen in but few places, owing to the deep alluvial deposit with which they are covered. It is very clearly defined in the neighbourhood of Ballinakill, on the edge of the Castlecomer road, and also at Cullenagh, where it is inclined to the horizon at an angle of 7°,—the strike being N. 22° W.

The principal collieries are the Doonane, Newtown, Towlerton, Nuragh, and Rushes: in all these the coal called the 3-foot seam is chiefly sought. This seam is not of a regular thickness, being sometimes less than two feet thick. This change, and the variable quality of the coal, has led to the supposition that the coal found in the Rushes colliery is not the same seam as that found in the Newtown. I have carefully examined these collieries, and am satisfied that I am correct upon this point, as reference to the sections will show.

There are, as far as I can discover, in the district included upon the map (Towlerton excepted), four regular beds of coal,—all anthracite: viz., the foot-coal, which is the lowest bed; over it the 3-foot coal, then the double seam and at top of these the 9-inch seam. I will proceed to describe them in their proper order.

The foot-coal is but of little value, and only worked near the outcrop; it underlies the 3-foot seam, at a depth varying between twenty-five and forty-five yards.

The 3-foot seam is of considerable value, and has been much

worked. Unfortunately, owing to the careless manner in which this seam was formerly wrought, a great portion of the coal has been lost; and, now that the supply is nearly exhausted, the proprietors have at length had their eyes opened, and are carrying on their works in a more systematic, and, of course (comparatively speaking), in a more profitable manner.

Owing to the method formerly adopted, the whole country is studded with pits,—they being sometimes not more than sixty yards apart. The hurrying roads were so very defective that the coal could not be carried to the shafts for any considerable distance. Pillars of enormous size were also left, which, now that the coal is becoming scarce, are being removed; but the expense of re-opening the collieries for the purpose is very great, and, consequently, none but the shallow parts are searched.

The double seam, as far as I could find, occurs only in the Rushes and Newtown basins. It is composed of two beds of coal,—each bed being about one foot in thickness, having a bed of fire-clay of one foot between them: it is not wrought, as the quality is inferior.

The outcrop is only visible in the Furnans quarry, where the beds are highly fossiliferous.

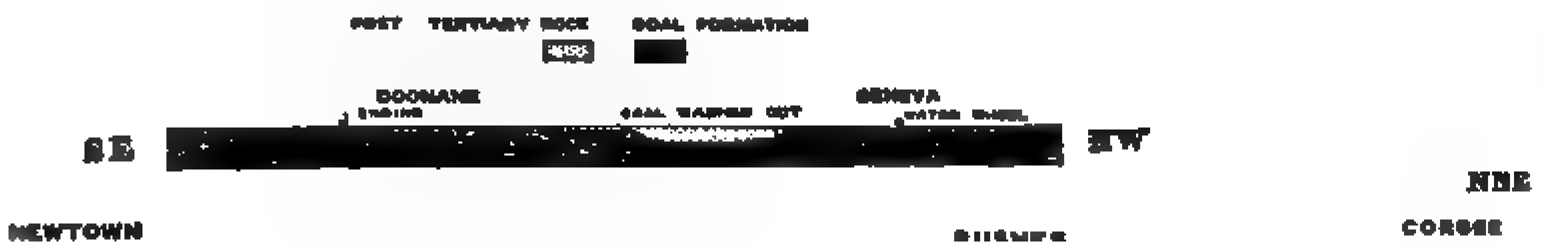
The 9-inch seam only occurs in a few places, and can hardly be considered as a regular bed: it thins out sometimes to two inches, but in no place is it thicker than nine inches. Each of these beds of coal is underlain by a bed of fire-clay of very superior quality; it is generally about three feet in thickness. It is strange that such a source of wealth should have been neglected, when its removal from the collieries would have considerably facilitated the excavation of the coal, and when its great value was pointed out so far back as the year 1814 by Mr. Griffith, in his able Report on the Leinster coal district.

Mr. Edge, some short time since, erected a kiln, and burned some bricks, which were quite as good as those imported from the English collieries; he did not, however, exert himself to obtain a market, and as soon as he had made what he required for his own use he gave up the manufacture.

Mr. Wandesforde, the owner of the greater part of the Kilkenny coal field, has erected a brick and tile factory at Castlecomer, and though he uses the common brick clay of the neighbourhood

SECTIONS TO ILLUSTRATE MR. JACOB'S PAPER ON THE LEINSTER COAL-FIELD.

SCALE,



SECTION TO ILLUSTRATE MR. DOYLE'S PAPER ON THE SALT MINE AT DUNCRUE

1. Chalk.
2. Greensand.
3. Saliferous Beds, 100 ft.
4. Red Rock Salt, 22½ ft.
5.
6.
7.
26½ ft.
8. Pure Rock Salt, 30 ft.
9. } Ironstone, Freestone, Grey Rock not
10. } yet bored through, 92 feet.

in large quantity, he has never, as far as I could discover, given the fire-clay a single trial. The land in the coal district is in general of fair quality, but (owing to a very retentive subsoil) it is of little value unless thoroughly drained. It is only within the last few years that the drainage system has been adopted, and the consequent improvement is visible to the most casual observer.

To understand the geology of the entire Leinster coal field would require years of study and careful examination, which I am sorry to say I cannot devote to it; but should these remarks lead others to examine into our native industrial resources, I will feel that I have done my duty.

March 9, 1853.—"Notes on the Salt Mine at Duncrue, and Searches for Coal by the Marquess of Downshire;" by J. B. DOYLE, Esq.

THE scene of the present operations in search of coal by the Marquess of Downshire lies about two miles north-west of Carrickfergus, and about a quarter of a mile from the valley of the Woodburn River, in the middle division of the county of the town, at a point about 300 feet above the level of the sea.

The entire of the Antrim coast presents a series of mural precipices, against which there abuts an extensive mass of vegetable soil, descending to the very margin of the sea, with inclinations more or less steep, according to the distance. This recumbent mass is generally of great thickness, as in the present instance, and is formed of the *debris* of adjacent rocks and the beds of the gypseous marls of the new red sandstone formation, which lie between the mountains and the sea.

The order of the strata is very plainly developed in the face of the escarpments, and consists of tabular trap, resting upon the white chalk and greensands, beneath which are the lias and new red sandstone series.

The new red sandstone is not very common in Ireland, being principally confined to the basaltic formation of the north, and to a small district in the County of Monaghan, in the vicinity of Carrickmacross.

Its principal development in Antrim is in the valley of the

Lagan, and at Carrickfergus, on the north shore of Belfast Lough. The series has been computed to be from 1800 to 2000 feet thick, consisting of a large proportion of shales.

The sandstone strata are very thin, and are variously coloured,— the reddish-brown predominating, intermixed with others of a bluish-gray, green, or yellow colour.

The same formation is traceable on the shores on the opposite side of the Lough, between Cultra and Hollywood, where thin beds of magnesian limestone alternate with the new red sandstone beds. The limestone is much denuded by the action of the sea, as it all lies below the high water-mark.

On the Antrim side, the beds attain a considerable elevation: the general strike of the strata is to the east, dipping north.

As the new red sandstone lies immediately above the coal measures in England (where the formation attains its greatest expansion), it has become one of the special sites of manufacturing enterprise. Not less than seventeen or eighteen principal cities and manufacturing places are situated on it, or upon the strata belonging to it.

It is no wonder, then, that in a district so remarkable for manufacturing enterprise as the north, repeated trials for coal should have been made from time to time, hitherto without success. The present researches are the most important and extensive that have yet been made, and are being pushed forward with an energy worthy of a successful result.

In the pursuit of this desirable object, a discovery of great interest and value has been made. About 600 feet from the surface an immense bed of the purest rock-salt has been penetrated, the entire series of the saliferous beds exceeding 200 feet in thickness. The salt has been pronounced to be of a very superior description, yielding from 95 to 98 per cent. of pure salt of commerce.

Some of the salt beds are of a beautiful blush colour, others white, and those mixed up in the shale bands are sometimes bluish or of a clayey-brown appearance.

As we have not had a previous opportunity in this country of making our acquaintance with the arrangements of this system, it may not be uninteresting to the members if I were to give the results of the borings at present in progress, which have now reached

the depth of about 900 feet, being nearly 600 feet below the level of the sea.

I am indebted to my friend Mr. Kelly, a distinguished member of this Society, for the following memorandum, made at the edge of the shaft upon the 10th September last, at which time the greatest depth obtained was about 700 feet:—

	Feet.
Diluvium, about 50 feet; red marl, 500; intermixed with thin beds of gypsum, ...	550.0
A thin stratum of rock-salt, ...	15.0
Salt and blue band, ...	6.8
Pure salt, ...	88.0
Blue and red band, with some salt, ...	17.0
Mixed salt, blue and red band, ...	13.0
Last salt, clean, but not yet bored through, ...	20.0
	709.8

These salt beds, from a very careful examination, are found to be conformable with the strata of the formation on the surface; so that it may fairly be concluded that the deposit is not a lenticular mass, confined to a single basin of limited extent, but a regular series of stratified beds: and if so, it is not difficult to calculate upon the out-crop at no great distance. The line of section, p. 231, is taken from the Toppin Hill, 928 feet above the level of the sea, running through the mouth of the shaft nearly due north and south to the Lough. This would give the out-crop about a mile and a half to the east, as nearly as may be ascertained from a section taken within the shaft.*

The probability is, that there are many such beds along the whole area of the new red sandstone formation, as it is well known that gypsum has been found at Colin Glen and at Cushendall. At Larne, as I have been informed by P. M'Garel, Esq., of the Maheramore Limeworks, borings were made in search of coal in the year 1839, of which a return has been forwarded; from which it

* A Company for working the salt mine has been recently formed in Belfast, and are now sinking a shaft near the Railway Terminus, very nearly in the place indicated above.

appears that thin beds of salt were reached at only 150 feet below the surface. These experiments were made in the town of Ballyedmond, about three miles from Larne, and near to the village of Glynn, where a salt spring has been known to exist for years. The salt reached was only eight yards thick; but, as the borings were discontinued at the depth of 174 feet, it is more than probable that the great deposit lies farther down. Between this point and the mine at Duncrue, at the village of Eden, there is another salt spring, which would lead to the supposition that the whole district between Larne and Carrickfergus, at least, contained a saliferous deposit. Since these notes were first made, a new salt mine has been discovered at Red Hall, lying within this district. But coal is the great object to be obtained. Reports of its discovery have appeared from time to time in the Belfast papers; but hitherto they have all proved fallacious, or at least premature.

I have obtained a Report of such a circumstantial nature, given by the engineer conducting the operations at the mine, that I am induced to give it: it wants verification, however, which I have taken steps to obtain. The borings are given as follows:—

Taking the gypseous marls as before, . . .		550
There follows, of workable saliferous beds,	100	
A stratum of red salt, ...	22¼	
Then a saliferous deposit, ...	26	
Pure salt, ...	84	
Mixed rock-salt, ...	14½	
Pure salt, ...	39	
Total saliferous, ...	——	286
Thin blue band, ...		6.6
Dark-coloured rock resembling ironstone, . .		4.0
Freestone, ...		10.1
Gray rock, not yet through, ...		2.4
Total, ...		859.1

One very favourable indication is present,—all the strata, so far, are conformable, which, according to Professor Sedgwick, is a very probable indication of the series running out into the coal measures.

In England, where the system is most perfectly developed, it

presents the following series of beds, according to the same high authority, viz.:—

UPPER BEDS, SUNK 600 FEET.

1. Variegated marls,—red, bluish, greenish,—with laminated clays, holding gypsum generally, and salt partially, as in Cheshire.

2. Variegated sandstones, the lower parts in some districts pebbly.

MIDDLE, 300 FEET THICK.

1. Laminated limestone, with layers of marls, gypseous and mottled.

2. Magnesian limestone.

3. Marl slates, soft and impure.

LOWER SERIES.

Red sandstone, red and purple marls, micaceous grits,—white, yellow, or pebbly.

"Where conformable," he adds, "this sandstone passes into the coal measures, upon which it rests."

How far all these members of the system may exist in the new red of the Antrim district will be a matter for examination.

The magnesian limestone, as we have already observed, is found alternating in thin beds with the new red on the shore near Cultra, in the county of Down; and perhaps a more careful examination of the same district will detect others of the series.

Another encouraging circumstance may be referred to. In the Tyrone coal field, near Dungannon, the new red sandstone rests upon the coal, unconformably, however; and although more extended observation establishes the conclusion that there is no determinable order applicable in all cases as to the nature of the rock that overlies the coal,—as it may sometimes be a slate clay as well as a sandstone,—yet, in reference to the efforts now being made, it is so far encouraging to know that not only is there no impossibility, but there is a strong probability, of a successful result, founded upon the geological conditions already noticed.

April 18, 1858.—"On the Quartz Rocks of the Northern Part of the County of Wicklow, by JOHN KELLY, Esq."

WHEN the Ordnance Geological Map of the county of Wicklow was published, it appeared to me that one of the sections accompanying that map was erroneously conceived and drawn; that is the section passing in a north-westerly direction through the Great Sugarloaf near Bray. In that section there are shown above twenty beds of quartz rock alternating with slaty rocks, and this I look upon to be a mistake. It was with a view to get this corrected that I put together the observations in the present paper, and describing such facts as my memory supplied, to show that the views I entertained were borne out by those facts.

After the paper was written I gave it to Mr. Oldham to read, previously to giving notice of its being read in this Society, that he might be prepared to defend the views put forward in the section, but immediately after, he made arrangements to quit this country, and the subject dropped. However, if the section be incorrect, as I believe it to be, it is well to correct it at any time.

As the subject of this paper lies chiefly in the northern part of the county of Wicklow, it may be well to give a short description of the rocks in that vicinity.

The rocks of Bray Head belong to the lower part of the old graywacke series, which is now called "The Cambrian rocks" by the English geologists. They occur generally in well-defined beds, of a hard, gray, coarse-grained, siliceous rock, averaging two or three feet in thickness, those often alternating with beds of gray slate, or red slate, only a few inches thick. This hard gray rock has recently got the name of "quartzite," but this name must not be confounded with "quartz rock," which here is of a whitish yellow colour, and totally different from quartzite in mineral character as well as in colour. The quartzite beds are sometimes five, ten, or fifteen feet in thickness, and the slaty beds as much, but these cases are the exceptions to the general rule.

Quartz rock in Ireland occurs in two different conditions, stratified and amorphous. Stratified quartz rock occurs abundantly in Donegal, Mayo, and Galway counties. The unstratified or amorphous kind occurs also in those counties in certain localities; but it is this kind that chiefly occurs in the counties of Dublin

and Wicklow, and also at Wexford. Both kinds might be got in hand specimens, extremely similar to each other in colour, fracture, and texture, but, as seen on the great scale where they occur in the country, the two kinds present a striking difference.

I shall select one or two particular districts for description. Stratified quartz rock is found along the northern coast of Mayo, stretching from Broadhaven eastwards to Glenlossera, a distance of fourteen miles, and extends from the shore inland from three to five miles, thus comprising an area of above fifty square miles. This is called the Glenamoy district, from the river of that name which flows through it. Here on the shore the stratification is well exposed, and the beds beautifully regular, averaging from ten to fifteen inches in thickness, having micaceous partings, by means of which they are easily separated into large flags, having remarkably smooth surfaces. The rock in this locality appears not to have been much disturbed. It dips pretty uniformly at a small angle, about 15° to 25° to the south-east, and under mica slate, thus showing it to be older than the mica slate of that district of Mayo.

In Donegal, the stratified quartz rock is found in contact with, and lying upon granite at rather a small angle in several places, namely, near Malin Head and Dunaff Head, in the barony of Innishowen; in Kilmacrenan barony near the coast, north of Rossnakill; at Glen; between Ballyness Bay and Claudy river; on the summit of Bloody Foreland mountain, the north-western part of the county; again at Maghery, three miles south-west of Dunglow, and in the island of Arran, altogether forming a line of junction with granite of above thirty-five miles in length. The quartz rock in most of this line is stratified, the beds dipping at a low-angle to the south-east, and succeeded by mica slate, conformably; all showing the quartz rock here also to be older than the mica slate.

Since granite comes in contact with every rock occasionally, no reliance can be placed on this long line of junction for determining the age of the quartz rock; but the fact that it is found both here and in Mayo,—dipping conformably under the mica slate, in such extensive areas,—is a proof at least, that it is the oldest stratified rock in either of those counties.

A second band of quartz rock occurs in Donegal, a few miles from this first, and parallel to it. It is four to five miles in breadth, and above forty-five miles long, extending from Culdaff, by Carn-

donagh, Buncrana, Rathmullan, and Letterkenny, and ending near Fintown. A band of mica slate separates those two bands of quartz rock. Along the north-west margin of this second band some of the dips would indicate that it succeeds the first mica slate conformably, and on its south-east margin it is succeeded by what has the appearance of a second mica slate, which extends over the south-eastern half of the county, and also into Londonderry and Tyrone. Whether there be really two distinct bands of quartz rock, or whether the second is an upthrow of the first, bounded on the north-west margin by a long, straight line of fault, cannot easily be determined. The latter is probably the case, as this north-west margin is nearly in a straight line with the edge of the granite district, from Ardara to Fintown, produced north-east in the strike of the stratified rock.

Such a fault would produce the appearance of two bands of quartz rock here, where only one formation really existed; for the granite, hot, liquid, expanded, and elevated, would have cooled and hardened first round its external margin, at the junction with the other rocks, and gradually inwards towards the central axis of the ridge. While this gradual cooling and consequent shrinking were going on, the central parts would have dropped down by those fissures, as the mass contracted more than the exterior, where it first cooled and became solid; and this would account for those two bands of quartz rock, *that* next the granite having slipped down with the granitic nucleus, and left the external margins on a higher level.

Something of this kind may be traced in the county of Dublin, in the limestone district. All the beds of limestone in the level country from Donnybrook, by Rathgar, Kimmage, Crumlin, the Fox and Geese, &c. &c., dip towards the granite, which lies southward, instead of being found in the horizontal position in which we must presume they were originally deposited.

In the neighbourhood of the Glenamoy district, at the west side of the great lake of Carramore, amorphous quartz rock occurs in the townland of Rathmorgan. Here it rises into a large hill, 768 feet above the level of the sea; and this makes a striking feature where the surrounding country is rather flat. What is worthy of remark here is the occurrence of this amorphous mass in the vicinity of the low, flat, and stratified district of Glenamoy, leading to the inference of a common origin here for both kinds of this rock;

that the hill has been protruded from a lower level, through the overlying strata; and that it originally formed part of the base of the great mass, though now found in contact with and even on a higher level than the superior beds which surround it.

The quartz rock of this hill appears to be identical in character with the quartz rock of the Sugarloaf district of Wicklow, of Howth, and of Forth mountain in Wexford. They are all of the same yellowish white colour, the same fracture, the same aspect, and the same general absence of sedimentary lines.

I do not mean to say that quartz rock is not found interstratified with mica slate; on the contrary, thin bands of quartz rock, from ten to fifty feet in thickness, are often found alternating with beds of slate. They occur so in numerous instances in the neighbourhood of Clifden in Connemara, and also in Glenamoy in the county of Mayo, near the junction of the quartz rock and slate district; but generally downwards from the junction, in the quartz rock, there is no slate seen, and the overlying slate contains no quartz rock. The cases where they are interstratified are few, and might be called the exception. In all these bands there is no doubt of the true sedimentary character of the rock, the beds being distinctly visible. What I would endeavour to show is, that the quartz rock of the Sugarloaf district in Wicklow is not of this kind.

From the foregoing facts I infer, that the quartz rocks of the Sugarloaves and Howth are not like those alluded to in Mayo and Donegal, in their original position with regard to the adjacent rocks; that they do not alternate with them, as shown in the Ordnance section through the Great Sugarloaf, but that those great masses, now brought in this locality to the surface, were once joined to, and formed a part of, a regular system of stratified quartz rock lying below the gray slaty rocks, as they are now seen in Mayo and Donegal; that they were in this position rendered semifluid or plastic by subterranean heat, and protruded through enormous fissures made in the overlying graywacke by volcanic or other expansive power from below; that the sedimentary lines of the former beds have in a vast majority of cases been wholly obliterated, but that in a few cases faint traces of such lines are still visible, as they are in other metamorphic rocks, which are believed to have been in a semifluid state, and yet bear slight marks of former stratification, such as porphyries, slaty greenstones, and even granite itself, which in some

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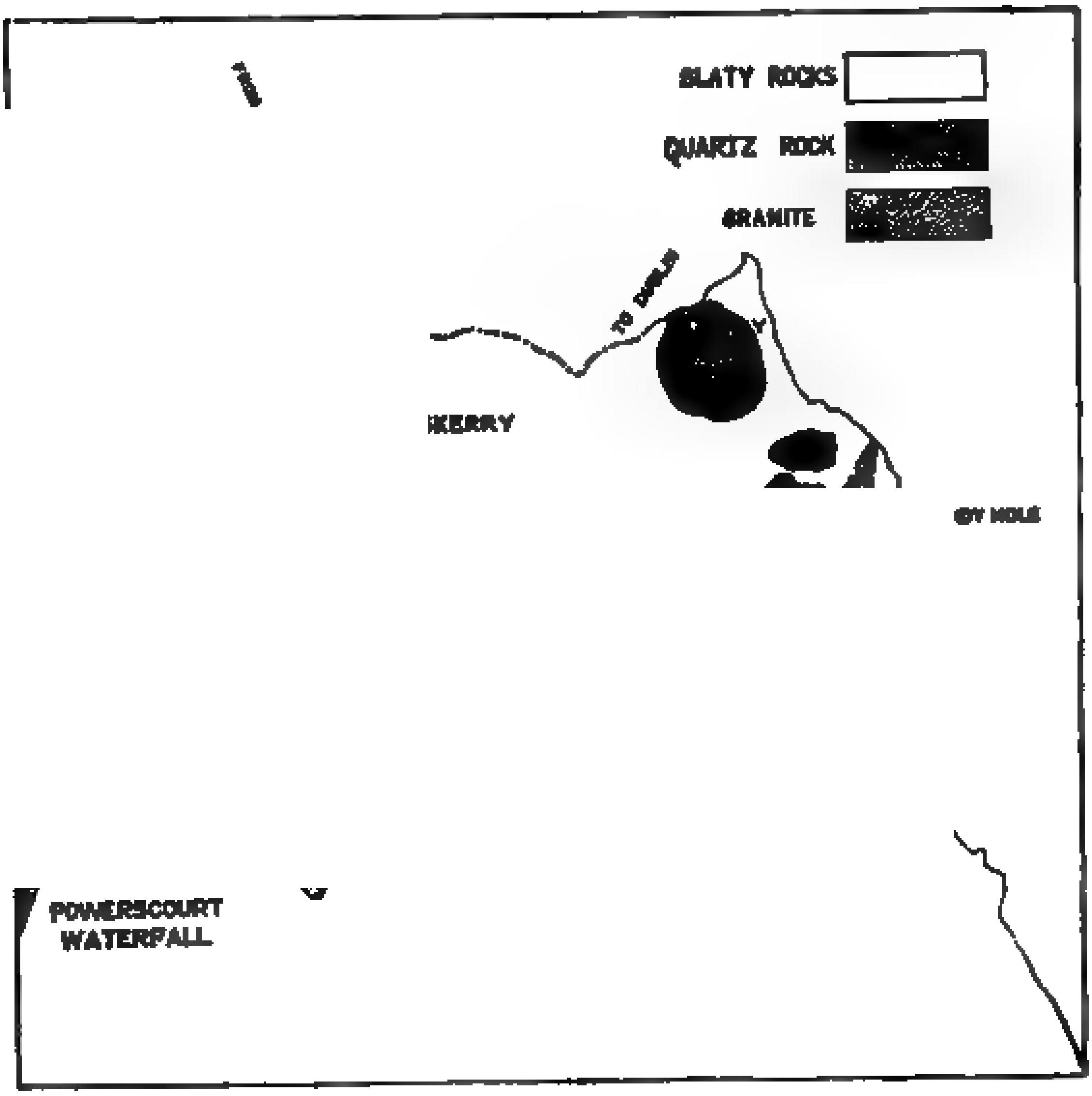

localities shows decided traces of bedding, and the interior of the beds is of coarse crystallization. This latter fact may be well seen in the townland of Dunlewy Near, on sheet 43 of the Ordnance Map of Donegal.

Stratified Granite at Dunlewy Near. Sheet 43, Donegal.

Any one who looks at the accompanying map of the vicinity of the Wicklow Sugarloaves will see, from the extent and form of the several masses, and the spurs and forks emanating from the main body of the quartz rock of that locality into the adjacent graywacke, that they never could have been produced by ordinary sedimentary deposition.

Though, perhaps, not a strong point to be relied on, yet it may be mentioned, that the rugged outline of Bray Head bears a strong resemblance to the outlines of many ridges of hills in Donegal, in the vicinity of greenstones and porphyries in that county, and more especially in the neighbourhood of Rathmullan.

Stratified quartz rock, such as occurs in Donegal, Mayo, and Galway, is not found in Wicklow, so far as I know; but since it is generally under the slaty rocks in those counties, there is no good reason to suppose it is absent here. It may be, and probably is, under the slate in Wicklow, as well as in Mayo.

From Rathcoole, by Dunlavin to Castledermot, the slaty rocks generally dip S.E., and the accumulation of the strata is from the Chair of Kildare towards Dunlavin, the upper beds coming in contact with the granite on its western margin here; and it is remarkable that on this side there is no quartz rock. So also from Aughrim and Carnew, southward through Wexford, it is the upper part of the slaty rocks that lies in contact with the granite of Mount Leinster, and there is no quartz rock there; thus following up the ana-

logy in Mayo and Donegal, before alluded to, of the absence of quartz rock in the upper part of the slaty rocks. But in the north of Wicklow, about the Sugarloaf hills, the case is different. Here the rocks belong to the lowest strata of the Cambrian group, as before stated.

Along the granite border from the Scalp, near Enniskerry, to Roundwood, the gray stratified beds of rock dip south-east, from Bray Head by Newtownmountkennedy they dip north-west, in the contrary direction; thus forming a synclinal valley along the line from Roundwood to Bray: and in the bottom of this synclinal trough it is that the largest masses of amorphous quartz rock in Wicklow, that is, Drumbawn, the Sugarloaf hills, and the masses about Bray Head, make their appearance. In the protrusion of those great masses the superincumbent strata were uplifted and fractured, and the whole of the upper part of the slaty rocks corresponding with that on the Dunlavin side was carried away by denudation, leaving only part of the Cambrian strata behind, which is now well exposed in the railway cutting at Bray Head; those strata intermixed in a confused way, but not interstratified with the amorphous quartz rock masses of that vicinity as we see them now.

I shall now enumerate the principal masses of quartz rock in the south-east of Ireland, and afterwards notice such facts in the vicinity of any of them as bear upon the subject. They are—

1. The Hill of Howth, a roundish mass, about two square miles.

2. The mass in which are the Greater and Lesser Sugarloaves, about four square miles. This mass is rudely circular, and is the largest in Wicklow.

3. Shankill, near the Scalp, a long, narrow mass, about half a square mile.

4. Bray Town stands on one of those protrusions. The form of it is nearly circular, and it is about one-fourth of a square mile.

5. Bray Head. This is a long, narrow mass of rock, forming a fork at the south end. It is about a mile in length by from a furlong to half a furlong in breadth, making one-eighth of a square mile.

6. The Brandy-hole protrusion, half a mile south of Bray Head, a long, narrow, crooked, irregular mass, about one-fourth of a square mile.

7. Walker's Rock, an elliptic mass, lying half a mile west of the Great Sugarloaf, and occupies an area of about one-eighth of a square mile.

8. Drumbawn, a low district, about two miles N.W. of Newtownmountkennedy. It occupies about one and a half square miles.

9. Dunran Hill, three miles south of Newtownmountkennedy, an irregular roundish mass, about three-fourths of a square mile.

10. Rathmore, crosses the mail-coach road two miles north of Ashford. This is a long, narrow strip like a dyke, in area about a quarter of a square mile.

11. Carrickmacreilly. The quartz rock in this mountain is mostly formed into long, narrow stripes, some a mile long by half a furlong in width; frequently a row of hummocks in a line, with hollows between them. There are several masses, which in the aggregate occupy about half a square mile.

12. Ballinacor mountain, five miles south-west of Rathdrum; about one square mile.

13. Forth Mountain, running from the town of Wexford to the south-west, comprising an area of about twenty-two square miles,—the largest in Leinster.

Besides the above there are numerous others; indeed, there may be counted on the Ordnance Geological Map of the county of Wicklow two hundred and ninety-eight of these small masses, lying in the slaty strata along the eastern boundary of the granite, and in its vicinity. Those small masses are generally shown as of a lenticular form, about half a mile in length by a few perches in width. They are shown lying lengthwise in the strike with the slaty beds, thick in the middle, and getting smaller towards the ends, and agreeing in shape exactly with the greenstone protrusions and elvan dikes, which also are marked in the vicinity of the granite, and appear to take the places of the quartz rock masses as they proceed towards the south from Aughrim to Carnew. Indeed, on the Ordnance Map it appears that the Aughrim river, which runs eastward by Arklow, and in the line of which there is shown a great fault or shift, cuts off the Cambrian rocks and the accompanying quartz rock masses near the granite, and divides them from the upper Silurian rocks, with their accompanying elvan dikes, which seem to be the protrusions of these latter rocks, and which lie all to the south of this place in contact with the granite, as the Cambrian do northward from that place to Killiney; thus showing that the quartz rocks are associated with the lower

part of the graywacke or Cambrian rocks through all the district. It is the same about Forth mountain in Wexford.

I shall now be more particular in describing a few of the separate masses, and begin with one of the most remarkable, that which is seen on the shore half a mile south of Bray Head, at the Brandy-hole, a name well known to the country people since times when smuggling was practised. There is a good section of the rocks here, in the cutting for the Wicklow railway, at the mouth of the Brandy-hole tunnel. The quartz rock at this place resembles a great bed, about fourteen yards in thickness. It lies conformably with the stratified beds, and dips conformably with them to the N.W. at an angle of about 60°; and certainly, if examined only at this spot, a geologist at first sight would pronounce it a bed of rock, regularly deposited in order, with the beds in contact with it, and not a dyke or protrusion of plastic or fluid matter. But dykes of foreign matter are frequently found running a long way between two beds of rock. Trap dykes are seen at Scrabo quarries in the county of Down, in sandstone, and at Carlingford in limestone, running in this manner between two beds, preserving an exactly uniform thickness for several yards in length, and then turning suddenly away in another direction through the quarries, cutting across other beds.

In the mass of quartz rock at the Brandy-hole there are no traces of stratification. From this place it passes westward up the hill, forming a rough, elevated crest, and rises, at half a mile distance from the shore, to a height of 793 feet, thence it descends to the village of Windgate, which is a mile from the shore. In this mile the mass preserves the long, attenuated form of a dyke, but in width it is very irregular, and so far unlike the true beds about Bray Head. It varies from 14 to 50, 100, and in some places 150 yards in thickness. In this course also, though preserving the same general direction, it is disturbed in its continuity, apparently by horizontal shifts. There are two places, as may be seen on the map, where it is only a few yards wide, and a third where it is quite separated at the surface of the ground from the rest of the mass, which soon rises up again, forming a steep, rough rock. When the observer arrives at Windgate, he will find that the mass does not pursue the direct course across the road, as might be expected in following it from the shore, but takes a turn southward, crossing the strike of the graywacke beds, which here lie at both sides of it,

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and are well exposed to the eastward, between it and the shore. From this turn southward it increases in bulk, forming a hill 532 feet above the level of the sea, and 200 yards wide across at the summit. It then descends southwards, through Templecarrig Lower, into the valley, then turns westward under Belmont House, and thence northward through the plantation, where it terminates in a narrow point.

Now, this Brandy-hole quartz rock mass is one of my strongest facts to show that this quartz rock is not in its original natural position, but is an intruded mass, although at the sea-shore it appears to lie in the gray Cambrian beds conformably.

In the area which lies to the south of this mass, and between the shore and Windgate, the strike of the beds is nearly east and west, and the dip 60 to 80 degrees north, both being persistent and regular over this area of nearly a mile, in its east and west direction, by a quarter of a mile average width, from north to south. The beds in the northwest angle of this area are broken off, and at Windgate village, where the quartz rock takes a turn to the south, it overlaps their broken ends, and separates this area from another area of similar rock lying west of the road, thus forming a great intruded mass of yellow unstratified quartz rock, between the two fields of stratified gray rock, and, as was said before, cutting across them, and separating them—and bearing some resemblance in idea to the skeleton of a horse, the backbone being represented by the quartz rock, and the ribs by the graywacke beds, aiming at and striking against it on both sides.

It might be argued. that at Windgate, where the quartz rock mass takes a turn southward, nearly at right angles to its former course, the stratified rocks turn also with it, and bend parallel to it, all forming a curve together; but this is not the case. Take the point *a* on the accompanying map, where the stratified rock is visible, and follow the strike eastward to the shore at *b*; from this point *b*, where the strike cuts the shore, to the Brandy-hole, is about sixty perches. If the stratified rocks curved round, to conform to the shape of the quartz rock, there ought to be this distance of sixty perches between where the stratified rock is seen at *a*, and the next quartz rock, which is seen at *d*: this is a space in which no rock is seen; it is a tilled field, the rock being covered with gravel and soil, but it is clear that even if the beds did turn

round here, there is not room between the point *a*, where the stratified graywacke is visible and persistent with that of the area lying eastwards, and the point *d*, the nearest quartz rock visible which, is only seventeen perches off here, while the thickness of graywacke beds which should fit in this space, if there were no break in them, and that they turned round in the angle, should be above fifty five perches. In fact the mass, in its progress from the Brandy-hole to Windgate, in its general direction shifts southward a little across the strata, cutting the ends obliquely at a small angle, but from Windgate southward, where it takes the turn, it cuts across the beds nearly at right angles. This could not have been the case if the quartz rock mass had been deposited in a sedimentary way, with the gray beds.

It will be understood from these observations, that according to the views I take, this mass of quartz rock is a protrusion of the rock, in a plastic or semifluid state, through orifices or fissures made by subterraneous movement, in the solid rock which lay over it. From the general shape of the mass, and the manner in which it lies with the accompanying well-defined stratified beds, sometimes parallel to them, and sometimes breaking through, and crossing them irregularly, I cannot come to any other conclusion; besides I have more facts to draw upon in support of these views.

A glance at the map, where the dips and observations are all marked in their proper places, will show all that relates to this important mass, better than further description.

The Bray Head protrusion lies about half a mile north of the Brandy-hole ridge, and is nearly similar to it in length, breadth, and general form. It rises from the shore to a height of 653 feet, and, forming a row of hummocks, presents a rough irregular outline, passes westwards down the hill to Ballinamuddagh village. At this place it throws off a branch to the south-west, which forms a fork with the main line. This branch terminates at 120 perches from where it sets off, and the main line ends in the valley of Kilruddery demesne.

Near the summit of this ridge, convenient to Bray Head, there are two low passes through the narrow, steep quartz rock ridge, and these are occupied with slate; but they have each the appearance of being only a thin, superficial patch, stretching across the hollow, and joining the greater mass of slate on both sides of the ridge.

Between the Brandy-hole ridge and the Bray Head ridge, in the townland of Ballinamuddagh, there are three small masses of quartz rock, which are pretty much alike in size and form; a description of one of them will serve for each. The middle one is about 350 yards in length, 88 yards wide at the west end; 66 yards in the middle, and 50 yards at the east end. It has the appearance of lying in the stratified beds conformably, being parallel to the strike; but if a sedimentary bed, the two ends of this mass would be prolonged in an attenuated form, and end in a point, which is not the case. At each end the termination is rather abrupt, and the mass is not produced eastward to the shore, because, if it were, it would appear in the line of railroad, which is only 30 perches from it, and where all the beds of the hill are visible, being cut across, and this yellow bed is not where it should appear if produced. The railroad is only 150 yards from where they disappear on the north-east brow of the hill. There is little doubt but those three small masses lie in the strata, and are partially conformable with them, and if so, the apertures which received the plastic matter from below were made by a separation of the beds along the sedimentary joints, with some fracturing of the strata at the ends where they terminate abruptly.

The quartz rock mass of the Great and Little Sugarloaf hills, as before stated, occupies an area of about four square miles, and within this area, as shown by outline on the map facing p. 241, I believe no slate exists. The two hills are included in this mass, as well as the space between them, and round their bases for some distance.

As in most geological sections, the Ordnance section passing through the Great Sugarloaf passes across the strata, nearly at right angles to the strike. In seeking, therefore, in the country for an exhibition of the alternations of quartz rock and slate, shown on that section, an observer would naturally follow the strike of the beds; that is, proceed either in a S.W. or N.E. direction, to some ravine or place where the rock should be well exposed. A favourable place of this kind is found in the valley through which the road runs westward from Kilmacannoge chapel towards the waterfall. The direction of this road is east and west, and across the strike of the rocks of the district, and as it runs along the northern brow of the Great Sugarloaf mountain, this is a place where, if those alternations existed, they would be visible.

Draw a line from the trigonometrical station, on the summit of the Great Sugarloaf, to Kilmacannoge chapel. This line has a north-easterly direction, and is nearly in the strike of the stratified beds of the surrounding country; and not far from the average of the direction of the eastern slope of the mountain itself, which is shown to be the last or most easterly bed of quartz rock on the section. This same bed, then, should be found at or near the chapel, and westward from it on the road side should be found the alternations which are shown upon the section; but not one of them is there to be found for half a mile west of the chapel, or until we get beyond the distance from the chapel, that the alternations are shown to exist westward from the summit of the mountain.

Again, it may be said that those alternations of slate exist in lenticular masses, and disappear in wedge-shaped points, before they reach the Kilmacannoge road. Take the line of section itself, and westward on this line for about twenty-five chains, or 100 perches from the summit, all the rock seen is quartz rock; but in this 100 perches distance from the summit, on the section, are shown nine bands of slate, alternating with as many bands of quartz rock; and since no slate is found in this distance on the ground, I think the section is incorrect.

There are indeed two longitudinal, rib-like masses of quartz rock on the west slope of the Great Sugarloaf, with slate between them, which might suggest the idea of alternating bands of quartz rock and slate; but these are not separate masses,—though they are separated by a band of slate in one place, they are joined and unite in another. I look upon them to be low ridges of the quartz rock, thrown up in relief on the edges of small faults or fissures in the underlying rock; and that the slate here is not alternating with them, but lying in thin superficial patches between them on the subjacent quartz rock of the mountain; the same way as it is seen on the eastern slope of the Little Sugarloaf, or on the summit of the Hill of Howth.

Another circumstance I think incorrect is this:—On the map the eastern slope of the Great Sugarloaf is all coloured as slate, with three very small lenticular masses of quartz rock in it. On the corresponding section the whole of the eastern slope of the mountain is shown as quartz rock. The map and section do not agree.

The east side of the Little Sugarloaf hill deserves some notice. The top of this mountain is quartz rock. Descending from this on

the east side, the rock continues downwards 120 yards. Then comes graywacke, and gray and red slate, dipping westwards into the hill, and about 100 yards thick; next a mass of quartz rock 125 yards; again, graywacke and slates as before, 140 yards, and dipping like the former at an angle of 70 degrees westward into the hill. The next is a prominent mass of quartz rock, about 80 yards thick, and from the lower side of this, to the valley, about 120 perches distance, no rock is visible, but slaty gravel is seen in the ditches. If alternations of graywacke and quartz rock are to be had, *this section is like them*, but the two bands of gray rock and slates thin out to a wedge-like point southwards, and the three bands of yellow quartz rock grow narrower at the surface northward, and terminate; and those alternate bands, therefore, though well seen on the slope of the mountain, are not alternating beds of rock, but quartz rock in its plastic state, which in its ascent got entangled with the masses of slate, and so lifted them to their present position. Those two very different rocks are, therefore, not interstratified with one another, but each one separate and independent of the other, thus forming the zig-zag junction shown at this place on the map. A section also conveying this idea is given below.

Section through the Little Sugarloaf Hill : Line East and West.
Scale of length, 2 inches to a Mile.

The junctions of those two rocks, where visible, are interesting. At all these, a man might stand with one leg on the quartz rock, and the other on the gray stratified rock, they come so abruptly together, and without any gradual passage from one into the other. A junction is visible at Ballinamuddagh, near the summit of Bray Head, at 100 yards south of the trigonometrical point shown on the Ordnance Map, and close by the side of the new road made by the

Earl of Meath. The slaty beds here are seen cut or broken across, with their ends abutting against the amorphous mass of quartz rock, nearly at right angles to its side. A plan of this is given.

Plan showing Junction of Quartz Rock and Gray Slate at Ballinamuddagh, near the summit of Bray Head. Scale, 10 paces to an inch.

Proceeding southwards from the place just mentioned, along the Earl of Meath's new road, at about 300 yards' distance beds of rock are again seen on the road-side, the strike and dip very clear, the strike being nearly at right angles to the axis of the Bray Head protrusion.

The unconformability of the graywacke beds and quartz rock would be much clearer in this district, but at the junctions of the two rocks there is generally a depression in the slate, owing to a tendency to decomposition at this place, the beds being much softer immediately at the junction than elsewhere, while the quartz rock retains its usual hardness in all parts. A good example of this softness in the slaty rocks is visible at the railway cutting near the Brandy-hole tunnel.

Here the slates, lying immediately over the quartz rock, are so soft for twenty feet away from the hard mass, that specimens taken at a considerable depth below the surface may be cut with a knife, some are grayish, some are red, but the prevailing colour of those soft slates is yellow, as they are seen lying on the quartz rock mass at the mouth of the tunnel. This yellow soft slate may have been altered, either by calcination from the vicinity of the incandescent quartz rock, or by the action of water, which is continually percolating through the loose fragments of the slaty mass in heavy rains. The latter is probably the chief cause, since the slates which lie under the hard mass of quartz rock are not soft, to anything near the same degree as those which lie over it.

Other localities in the district show the softness of the graywacke and slate rocks, at the junction with the quartz rock. In the cutting made to form the Earl of Meath's new road in Ballinamuddagh, near Bray Head, where this road crosses the three quartz rock protrusions before mentioned, such junctions are seen. In forming the road, the workmen, finding the material soft in certain spots, dug pits, and followed it into the side of the hill, to get stuff for making the surface of the road. Those pits are all in the slate at its junction with the quartz rock.

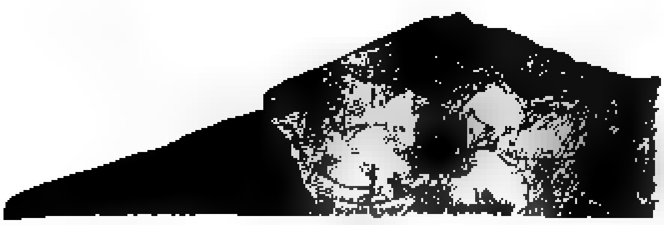
The softness, and the fragmentary condition of these slates at the junction, near the Brandy-hole and other junctions, are arguments in favour of the idea that some disturbance took place at those junctions since the original deposition; and that the quartz rock masses have been intruded, and were not originally deposited in the position in which we now find them.

At Ballydonagh, half a mile north of the Glen of the Downs, on the side of the road leading to Windgate, a junction of quartz rock and graywacke is visible, in which the slate lies unconformably on the hard rock. A sketch of this is given.

View showing Junction of Quartz Rock and Clay Slate on the Road-side at Ballydonagh, 3 miles south of Bray.

Something like veins of quartz rock are occasionally seen; at the Dargle, a mass of this kind, of long narrow form, occurs. It has all the appearance of a vein or dike emanating from the main body of the Sugarloaf mass. The steep rock called the Lover's Leap is on it. This is shown in the following view.

View in the Glen of the Dargle, near Bray, about two chains east of a Cottage on the high bank, south side. Here the junction of Quartz Rock and Gray Slate is unconformable.



The first of these two cuts is a view—the second a section of a junction of quartz rock and gray slate, a quarter of a mile west of the summit of Bray Head.

In the above drawing it is seen that the mass of yellow quartz rock is not conformable with the slate, but lies across the ends of the beds.

View of Quartz Rock lying on Slate, in the Glen of the Dargle, near Bray, south side.

Here the quartz rock joins the slaty beds conformably, and this fact tells rather against my views, but I shall not conceal anything.

Though not in the district, I may mention that, at Kellystown, two miles south-west of Wexford, near Rathaspick Church, a quarry has been opened. The rock here is chiefly gray slate, but there are four veins in it of grey quartz rock, and it is for these, as building stone, the quarry has been opened. Those veins are each about a foot thick. They lie nearly parallel to each other, and though nearly in the strike, yet they are not conformable with the slaty beds. A drawing of these is given herewith, which shows more

View, showing Veins of Quartz Rock, in Gray Slate at Kellystown, 2 miles south-west of Wexford.

clearly than can be shown by words how they lie with regard to each other, and to the strata. The lowest of those four veins, so far as it is exposed, lies quite conformable with the slaty strata; the upper one is not conformable anywhere, and the two intermediate ones are conformable with the accompanying strata in the upper part of them, and unconformable in the lower.

It has been stated that the Hill of Howth, which is of quartz rock, is composed of a series of alternations of graywacke with gray

and red slate, interstratified with beds of sand, which beds afterwards became hardened, and are now the quartz rock we see. I cannot accord with this view of the structure of that Hill. I have never seen any facts to induce me to believe that sedimentary alternations of graywacke and amorphous quartz rock are to be found anywhere. The quartz rock of Howth occupies an area of about two square miles. It is rudely circular on the plan, and appears to have been once a great cylindrical or perhaps rather conical mass, having graywacke on the top, and quartz rock below. That this whole mass was forced up by some expansive power from below, through the surrounding strata, of other kinds of rock, which skirt it round on every side. The line of coast from the Bailey Lighthouse towards the harbour runs north-east. It is parallel to the edge of the quartz rock, and it is in the strike of the graywacke beds, which dip away from that quartz rock at a very steep angle. So far there is nothing remarkable, but from the Bailey Lighthouse westwards along the coast are to be found the most extraordinary contortions, both vertical and horizontal, to be seen anywhere in strata. The beds are folded, both in elevation and in plan, in a manner certainly not to be accounted for by any imaginable process in ordinary natural deposition. They stand nearly upright, but they may have lain, and probably did once lie, horizontally on the mass of quartz rock, at a great depth; and as the mass of the hill was forced up vertically, those beds were broken off, one portion resting on top of the quartz rock mass, while the adjacent portions of the beds were uplifted towards a vertical position, being crushed and contorted in the vicinity of the moving mass.

Plan, Quartz Rock and Slate, near Howth, immediately east of the Needle Rocks. Scale, 6 yards to an inch.

Among a variety of examples, which may be seen on the southern shore of Howth, the foregoing figure is a plan of a spot, a few yards to the east of the Needle Rocks, which has been carefully surveyed. By inspection of the plan it will be seen that the graywacke beds are frequently broken across, and their ends overlapped by the yellow rock; so also on the west side in this plan, the ends of the slaty strata are broken off, and thus broken come in contact with quartz rock, while in other places where the beds are contorted, the quartz accommodates itself to them conformably, and lies in bands of equal

thickness, parallel to the sedimentary beds. The yellow rock here, like the mass at the Brandy-hole tunnel, appears to have been protruded through the slaty rocks in a semifluid state. There is no other possible way for accounting for the appearances. Bands occur of uniform thickness for several yards in length, sometimes parallel to the strata, sometimes cutting them across at right angles, and irregularly in the same manner as greenstone dikes do. In the larger masses, such as the Hill of Howth, the Sugarloaves, and Forth Mountain, although the stratification is obliterated in general, yet there are masses of the rock often seen, which show faint traces of sedimentary lines, leading to the conclusion that those masses were once regularly stratified, but subsequently altered. The smaller bands, however, do not present the slightest appearance of sedimentary lines.

I stated before that I considered the quartz rocks of Mayo to be of two kinds. Adding to the appearances, then, those in Wicklow, there would be three kinds of quartz rock; they are:—

1. The stratified rock, the original sedimentary arrangement of which appears never to have been altered. It occurs in masses of great thickness, as was said before, in Donegal, at Culdaff; it is well exposed on the shore and at several other places in that county; in Mayo on the shore for many miles in the Glenamoy district of Erris; and in Galway thinner bands about Clifden in Connemara.

2. The amorphous quartz rock. This lies chiefly in Leinster, the Hill of Howth, the Sugarloaves in Wicklow, and Forth Mountain in Wexford, masses also of very great thickness. Generally speaking, in this, the sedimentary lines are obliterated, but instances occur where faint traces of stratification are still visible, as at Walker's Rock, a mile west of the Great Sugarloaf, and two miles south of Enniskerry; also in the quartz rock immediately south of the town of Wexford, parallel joints on a large scale appear, which may be connected with the original stratification.

3. That kind of quartz rock which appears to have been protruded into fissures in the overlying gray rock. Such are seen in the contortions at the Needle Rocks, Howth; the Brandy-hole mass, already described, with other masses thereabouts; at Rathmore, two miles north of Ashford, in the hill of Carrickmacreilly, and many other places. In this kind I have never been able to detect any trace of stratification.

These three kinds of quartz rock are identical, at least in external characters: they are of the same colour, hardness, and fracture, and a hand specimen of one of them cannot be distinguished from that of another.

Objection is made to this view by the chemists, who say that quartz rock is not fusible before the blow-pipe, nor can it be affected by the ordinary tests used to reduce other rocks. This may be the case; but the Great Chemist who did this work is able to bring to bear upon His subject conditions not in the power of man. He can command any amount of heat; any amount of pressure, with the use or exclusion of air, water, gases, electricity, and other agents, to effect His object.

If the quartz rock of Leinster be an altered condition of such stratified quartz rock, as we find in Mayo, as I believe it to be, in which condition the sedimentary lines, so clear in Mayo, are obliterated, or nearly so in Wicklow, this obliteration of the lines of stratification must have been produced by a certain degree of softening of the original rock, say, to make it plastic. This degree, carried a little further by the same agency, would make it liquid, so that it would flow into any fissure in an overlying mass of unaltered rock that lay convenient when the great weight of a superincumbent mountain pressed upon it. In this manner I suppose the Brandy-hole mass was protruded; the openings in the contorted masses at Howth filled up, and smaller veins injected as at Kellystown and various other places.

View of Quartz Rock and Slate immediately south of the Town of Howth.

The view on the preceding page shows the upper part of a quartz rock mass, which is projected upwards into the slate. It ends in a wedge-like point. It appears on the east side of a bye-road, passes under it, and is connected with a large mass of the same rock which appears in a quarry, on the west side of the same road.

View. Quartz Rock and Slate at Sutton, near Howth,
6 chains North of Martello Tower.

Here the lower mass of quartz rock appears to lie conformably with the slaty strata, but is evidently a projection connected with the overlying rock, and all subsequently to the slate.

Plan, Slate enclosed in Quartz Rock on the Shore at Sutton, near Howth, 10 chains East of Martello Tower, Scale, 8 yards to an inch.

This sketch shows a piece of gray slate inclosed in quartz rock, and surrounded by it on every side.

View at Sutton, on the Shore North of the Martello Tower, showing Junction of Quartz Rock and Slate.

This sketch shows a mass of quartz rock lying on slate, in a section at Sutton, near Howth. The junction shows an evident unconformability. The slaty beds are broken off, and along the line of junction the quartz rock passes over the broken ends of the strata in an undulating line, although the general line of it is nearly in the strike.

Plan. Gray Slate in Quartz Rock at Sutton, on the Shore, 10 chains East of Martello Tower. Scale 8 yards to an inch.

This sketch represents a piece of slate enclosed in quartz rock. By inspection of the strata in the slate it is evident that the slaty mass has been disturbed; the smaller limbs appear to have been removed from their original position, for the sedimentary lines in them are not parallel to those of the main body.

The foregoing sketches I have selected out of a great number, as tending to show that the slate and quartz rock of the Howth and Bray districts are not now in regular sedimentary succession; but that the whole of these districts has been much disturbed, and in the course of this disturbance the quartz rock intruded into positions in which it was not originally deposited.

The area of the great platform of the Hill of Howth was, no doubt, at one time all covered with the slaty rocks, but they have been mostly carried away, little remaining but a few thin, superficial patches lying in hollows on the surface of the hard, yellow, rocky mass of the hill. All round this mass there must be a fault, along the line of which it was torn away from the corresponding

parts below, and the whole mass elevated to its present position. This, on the north side of the hill, is clear, where the limestone stands now at a low level on the shore, and in the demesne, while the quartz rock of the hill stands about 500 feet higher; the natural position of the quartz rock in the crust of the earth, as seen in Mayo, lying under the slaty rock, being several thousand feet below the limestone.

The same observation applies to all the large circular or elliptic masses of quartz rock in the district, where no slate is seen within the area of such mass to interrupt its continuity.

The thickness of the quartz rock in Donegal or Mayo it is difficult to ascertain, without a more minute survey than I have had opportunity to make. In Wicklow the Great Sugarloaf mountain is, by the Ordnance Survey, 1651 feet above the level of the sea, and the whole mass, from the summit to the base on the east side, is quartz rock, and probably far below the parts visible in the valley of Kilmacannoge. It may be two thousand feet thick or upwards in this locality.

In the counties of Wicklow and Wexford the slate along the margin of the granite for a mile or more in width is highly micaceous; beyond this the micaceous lustre becomes less, and at a few miles from the junction it disappears altogether; and as in Wicklow, so in Donegal, the mica slate of that country is probably the graywacke system altered in that locality. From examples before stated I take the quartz rock of Donegal and Mayo to be the oldest stratified rock we have in Ireland, and the quartz rock of Leinster, that is, Howth, the Sugarloaves, and Forth Mountain, its counterpart; and it is remarkable that in those localities it is associated with the lower part of the graywacke, or what is now called the Cambrian rocks.

While on the subject of quartz rock, it may not be out of place to notice, that our two great formations in Ireland, the old graywacke, and the carboniferous, bear parallel comparisons in many features. Thus the quartz rock in Mayo and in Donegal, clearly lying under the altered slates and limestones of that district, bears a resemblance to the old red sandstone lying at the base of the carboniferous rocks; and the mica slates and crystalline limestones of Donegal, which succeed the quartz rock, may be compared with the shales, limestones, and grits of the carboniferous formation also,—

the great difference being that in the old or graywacke system the quartz rock is excessively hard. The mica slate and the limestone, which is universally crystalline, all appear to have undergone a greater change, being more hard and consolidated than the members of the carboniferous formation, the latter being in general softer and more friable.

As I have just said, I suppose that the Hill of Howth was separated below from the parent quartz rock which lies there still, and was elevated to its present position. An attempt might be made to ascertain the amount of this displacement or upheaval.

In Poulscadden Bay, immediately to the east of Howth Harbour, the quartz rock of the hill is found adjacent to the carboniferous slate of that locality; and no doubt they are in contact, though the junction is not visible, being covered by gravel; thus those two rocks are brought together at Howth by the upheaval of the quartz rock; and as the natural position of this is below the graywacke, the amount of displacement must be equal to the whole thickness of the graywacke group, together with that of the old red sandstone which lies under the carboniferous slate. What, then, is this thickness?

Mr. Robert Harkness read a paper at the late meeting of the British Association on the Graywacke or Silurian rocks of the Grampians, and stated, that in the sections which he examined those rocks were at least 15,000 feet in thickness. Professor Nicol, of the Queen's College, Cork, read another paper on the same subject, but his examination was more extensive, and in a different part of the mountain group. From his observations he inferred that the thickness of the graywacke slates and grits exceeds 30,000 feet, or about six English miles. From sections I know in the county of Londonderry, and also in Cork, I believe this estimate of the thickness of the slaty rocks is not at all above the truth. Therefore six English miles may be taken as the lowest estimate of the amount of the fault in Poulscadden Bay, which brought the quartz rock and carboniferous slate into contact.

I have thus laid before the Society the views I entertain regarding the quartz rocks of Dublin, Wicklow, and Wexford, and hope by so doing that the attention of more able geologists will be drawn to the subject, with a view to the adjustment of such differences of opinion as various observers may adopt concerning those rocks.

May 11, 1858.—Results of an Analysis of Siliceous Deposits from the Hot Volcanic Springs of Taupo, New Zealand. By J. W. Mallet, Ph. D.

Incrustations of a siliceous character occur abundantly around the hot springs of the remarkable district of Lake Taupo, in the northern island of New Zealand, a district of which a most interesting account has been given by Dr. Dieffenbach in his Travels in New Zealand. Indeed, almost all the springs of hot water and mud of this region appear to hold silica in a soluble condition, and to deposit it on the surface more or less mixed with other matters previously dissolved or suspended in the water.

A specimen of one of these incrustations, I believe from the Lake Taupo region, although the particular locality is not stated, was analyzed by Mr. R. Pattison,* with the following results:—

Silica,	77.35
Alumina,	9.70
Peroxide Iron,	3.72
Lime,	1.74
Water,	7.66
	100.17

Whence Damour classes it along with similar deposits from the geysers of Iceland, under the formula 2 SiO_3 + HO, though, if the alumina, peroxide of iron, and lime, be supposed to have been combined with part of the silica, the mineral will be more properly represented as 3 SiO_3, 2 HO. But the presence of so large a percentage of foreign matter renders it difficult to assign any exact formula to this mineral.

The results of an analysis of a purer specimen which I have recently made differ widely from the preceding, and also from the composition of Geyserite from Iceland as given by Damour and Forchhammer. The specimen in question, which was subjected to examination, was a porous but compact concretion, opaque, and of a white colour, slightly tinged with yellow, very tough, and difficult to break, and intermediate in hardness between felspar and quartz. Its specific gravity was 2.031.

Digested in a cold solution of caustic potash it dissolved, though very slowly, leaving scarcely any residue.

* Philosophical Magazine, xxv. 495.

A portion of the mineral was dried at 212°, and then analyzed by fusion with carbonate of soda in the usual way.

Having digested some of the finely pulverized mineral in boiling water, I was surprised to find that on filtering and adding solution of nitrate of silver, a precipitate of chloride of silver was formed, showing the presence of some soluble compound of chlorine. A separate portion of siliceous sinter was then employed for the determination of the chlorine, and having thrown down the chloride of silver, and filtered, the excess of silver was removed by muriatic acid, and the solution again filtered was evaporated to dryness, when the substance in combination with the chlorine proved to be sodium. Nothing but chloride of sodium had been dissolved out by the boiling water, and by testing the portion thus washed it appeared that all the chlorine existed in the same state of combination, and had all been dissolved by the water.

The analysis yielded the following results:—

Silica, ...	94.20
Alumina, ...	1.58
Peroxide of Iron, ...	.17
Lime, ...	Trace.
Chloride of Sodium, ...	.85
Water, ...	3.06
	99.86

If 1.53 per cent. of the silica be deducted as having existed in combination with alumina and oxide of iron (as binary silicates), the relative proportions of silica and water in the mineral will be—

		Atoms.
Silica, ...	92.67	1.993
Water, ...	3.06	0.340

numbers which closely approximate to the formula 6 SiO_3, HO. This is much nearer to the composition of some varieties of hyalite and cacholong than to that of any of these recent incrustations of volcanic origin previously analyzed.

The occurrence of chlorine in deposits of this character has not, as far as I am aware, been before noticed, though potash and soda in small quantities have been detected, and were supposed to exist, as they probably often do, in combination with the silica. The ex-

istence of chloride of sodium, therefore, in this incrustation, and in appreciable quantity, amounting to nearly 1 per cent., appears to be a point of some interest, though its bearing upon the chemical geology of these volcanic springs could not be considered without more distinct information as to the nature of the springs themselves, and the circumstances under which the incrustation was formed, than I have been able to obtain.

May 11, 1858.—"On the Geology of Portraine, Co. Dublin;" by Henry B. Medlicott, Esq., of the Geological Survey.

The district I have to describe is about twelve miles to the north of Dublin; it is geographically, as well as geologically, isolated. It is bounded on the east by the open sea, on the north and south by two shallow estuaries, on the west I have taken as limits the mail-coach road between Dublin and Drogheda. The railway divides it equally.

The physical features are anything but striking. The boulder clay, and drift gravel, almost conceal everything, and, although their accumulation and subsequent modelling by degradation were much influenced by the position of the harder rock, they now give their characteristic rounded, undulating outline to the whole country.

The ridges of rising ground run nearly east and west, perhaps a little south of east and north of west. In the centre, or at either end of them, there is generally a support of hard rock, which acted as shield or buttress, or as both, in preventing the removal and levelling of the looser materials. The subjacent rock is only seen satisfactorily along the sea-coast, to the north-east, in the railway cutting, and about Donabate. The greatest elevation is near the coast, only 93 feet above low-water mark.

This district has never, that I could hear of, been made the subject of a special investigation. The name Portraine has for years been known to palæontologists as that of a locality for Silurian fossils, but the beds in which these treasures occur have never been described. The only preliminary information I have been able to obtain was from Mr. Griffith's general geological map of Ireland, and from the larger county map of the Government Geological Sur-

vey. On these we see at Portraine the colours purple, red, blue, and green, indicating the existence of Silurian, Devonian, and carboniferous limestone, with trap rocks. I will endeavour to trace out the connexion of these very distant relations, and to describe the peculiar features of each.

The Silurian rocks are only visible on the east, occupying an area of about a mile long by a third of a mile wide, the greater length being along the coast, running N. E. and S. W. (see Map p. 275.) They are nowhere seen in contact with other bedded rocks; the test of superposition thus fails in establishing their seniority; but we have as conclusive evidence in the striking contrast between the circumstances of relation of the igneous masses to them and to the other deposits. The trap covers as much ground as the Silurian rocks. It shows at the surface in four distinct spots, two in the middle of our map, and two on the east; these last may be said to enclose the Silurian beds.

The most general characteristic of the Silurian rocks is that of being highly calcareous. Their strike is N. E. and S. W., with a dip to the S. E. The uppermost beds consist of green, micaceous, exceedingly hard, calcareous grits, the beds being often four and even eight feet thick, with interstratifying beds of a fragmentary yellowish mudstone, which sometimes exhibits a defaced cleavage. Throughout these the stratification is comparatively undisturbed; there are several small slips and some sharp rolls, but, on the south, where they are most developed, and most removed from the intrusive rocks, they are not very complicated, and may have a thickness of about 300 feet. At extreme low water they can be traced up to the greenstone on the north, gradually losing all decision of character.

In the irregularities of the coast we get short sections showing the underlie of the strata. At the point where the deer-park wall reaches the shore, we see the strong grits resting on some broken and twisted beds of limestone and marlstone. The section has almost the appearance of original unconformability. A close examination, however, will show that, although twisted, each of the lower beds is still entire. The phenomenon is the same as that noticed to the Society last year by Mr. John Hamilton, and as I have often seen myself, occurring in the calp, where, in a synclinal trough, the thick limestone beds can be traced in a tolerably regular curve, while the interlying thin shales and mud layers have slid together into every

imaginable form of crumple. In the case of quartz rock this appearance has been mistaken for the unconformability of intrusion. Below the grits no continuous sequence of beds can be obtained, the disturbing action has been so great upon the more yielding materials. On the coast, south of the Martello Tower, we see in many places a thickness of from 20 to 40 feet, made up of the most regular alternation of compact, hard limestone, with a yellowish, imperfectly indurated marlstone; the layers varying in thickness from two to six inches. In places of violent contortion, the limestone bands have been shivered, and the softer layers have been squeezed between the fragments, giving to the mass the appearance of a great breccia. With these thin layers we have occasional thick, regular beds of limestone; fossils occur in both, perhaps more abundantly in the latter. The general dip is still S. E. at all angles. There are several small instances of inverted bedding.

Inland, the only rock which comes to the surface are thick masses of limestone. I am inclined to think that some of the most westerly of these have no representatives on the coast, not only on account of the greater thickness of the whole group in the centre, but also upon lithological grounds; they have a coarsely brecciated character, some a conglomeritic; pieces of shales, grits, highly micaceous limestone, with an occasional quartz pebble, in a pure blue limestone paste: large corals are mixed up with the stony fragments, but do not preserve any definite position in the mass.

All these sedimentary rocks strike into and between the several greenstone protrusions on the N. E., or rather were forced up and twisted by these, the mutual influence producing an endless variety of texture. The greenstone mass at the southern Martello Tower does not seem to have cut up the stratified rocks, but to have diverted the strike of them from S. W. to S. The greater igneous mass on the shore to the N., I would connect with that in the deer-park, and continue in a S. W. direction. I think we have here a clear case of cause and effect, in these igneous rocks having produced the present position of the older palæozoic deposits. May not the main elevation and strike have been caused by the great intrusion on the N. W., and the complicated contortions be chiefly due to the minor masses on the N. E. and S. W.? Whatever more remote cause may have struck out the lines of intrusion, and have given an initial direction to the general strike and dip of the beds, I cannot explain the

further facts of the case otherwise than by the immediate and direct action of the intruded rock. The course of events can have been on this wise: the lower calcareous breccias, with which are associated some layers of ashy aspect, but which may owe this to subsequent alteration, were probably the result of an early display of volcanic agency at Portraine; a period of rest ensued, during which were accumulated those extremely regular layers of mud and limestone, succeeded by the calcareous grits. What more took place we have no means of judging; the next invasion from below produced the state of things we now find. I have no reason for establishing different ages (in the extended sense of the word) for the intrusion of the several igneous masses of the district. In each we find every variety of colour and texture, gray, green, and red; porphyritic, amygdaloidal, flaky, compact, &c.; and each seems to bear the same relation to the sedimentary rocks. The feldspathic ingredient greatly predominates.

Palæontologists refer the Portraine fossils to the lower Silurian formation; many of the species are identical with those from the chair of Kildare, which latter Professor E. Forbes, in a notice communicated to the Society in January, 1848, considered as representative of the Bala group.*

I subjoin a list of the Portraine species mentioned in M'Coy's "Synopsis of the Silurian Fossils of Ireland:"†—

Leptagonia depressa, ...	*Dal. sp.*
Leptæna sericea, ...	*Sow.*
Orthis actoniæ, ...	*Sow.*
,, alternata, ...	*Sow.*
,, galea, ...	*M'Coy.*
,, porcata, ...	*M'Coy.*
,, testudinaria, ...	*Dal.*
Spirifer terebratuliformis, ...	*M'Coy.*

Cyathophyllum cæspitosum, ...	*Gold.*
,, dianthus, ...	*Gold.*
,, turbinatum, ...	*Gold.*

* There are many other points of resemblance between the geology of the chair of Kildare and of Portraine.

† Several of these and many others may be seen in the Museum of Practical Geology, 51, Stephen's-green, Dublin.

Porites pyriformis,	. . . .	*Ehrn.*
Favosites alveolaris,	. . . .	*Blainv.*
" polymorpha,	. . . .	*Gold.*
Halysites catenulatus,	. . . .	*Linn. sp.*
Syringopora lonsdaleiana,	. . . .	*M'Coy.*

The rock next by position to those we have been describing is a coarse red conglomerate, made up of pebbles, from the size of a goose-egg down, of quartzite and red grit, a typical example of what is familiar to every one as 'old red conglomerate': this, with other reasons, places it on the list of middle palæozoic formation.

I should like not to skip over such an immense period of geological time without attempting, in some degree, to fill the blank in positive evidence by a sketch of what must, from what we now see, have occurred. No doubt Nature was constantly busy producing or destroying; we can only speak with certainty of the latter. The Silurian rocks we have gone over are not such as we know to be of rapid or of local accumulation; they were spread over a wide area before the forces from below placed them in their present position; nor is it probable that the uppermost grit-bed now on the shore was always the last of his race. There was then at one time a vast amount of solid rock covering what we now find. This was all broken up and completely removed before the deposition of the first bank of red conglomerate. If one may speculate upon so remote a cause, it appears likely that the chief energy of the destroying agent was directed from the N. W.; it is only where they have been protected on this side by the tough greenstone that we have any vestige left of the older stratified rocks; but for the timely arrival of the effective screen of gravel we should not have had even this remnant. This supposition might serve, too, as a possible explanation of the position of the red conglomerate, and of the total absence in it of greenstone or of limestone pebbles. This latter fact made me suppose at first that the trap was newer than the Devonian beds, but I searched in vain for a confirmation of the idea. The actual junction of the conglomerate and the greenstone is not exposed; they are seen in several places within a few (from 5 to 20) feet of each other, and exhibit no adequate degree of disturbance or of metamorphic action; there is no intimacy between them, either by intrusion or by interstratification.

The surface of the present Silurian area has not been much altered

since the Devonian period; a very little less of recent denudation would have spared the original covering of red conglomerate; we find huge blocks of it in several places; it is only seen undoubtedly *in situ* in a few. In Newbridge demesne and about Donabate there is a very considerable accumulation; it rests against the greenstone, and has a general inclination to the N. and N. W. Where first seen on the south, in the railway cutting, it has the same inclination and the same relation to the greenstone close by. In Portraine demesne, and immediately north of it, on the shore, it shows itself again, in each case dipping to the N. W. from the greenstone. It has then all the appearance of having been deposited against and upon this reef of trap rocks.

The beds above the red conglomerate are very imperfectly seen; we have but a low, short section in the railway cuttings, and three or four quarries, as all evidence. In the southernmost cutting on the railway there is the following stratigraphically conformable sequence for a horizontal distance of about 500 feet. The lowermost, on the south, is the conglomerate before mentioned, 40 feet (horizontal); on it rest red arenaceous shales, 50 feet; hard, red sandstones, with shale partings, 40 feet; red concretionary marl and crumbling sandstone, 70 feet; a bed of greenish clay, 1 foot; crumbling red sandstone, with shale partings, 80 feet; thick bedded red sandstones, 20 feet; grey and red fissile shales, 30 feet; coarse, yellowish, calcareous and earthy sandstones, 25 feet; hard, siliceous limestone, 2 feet; alternating, thin, hard, and shaly calcareous beds, 20 feet; bed of compact earthy limestone, 2 feet; earthy septarian limestone, indistinctly bedded, 120 feet.

Professor Haughton has allowed me to insert an analysis he made of an average specimen from these upper beds:—

Argil, or insoluble residue,	58.77
Carbonate of iron,	18.21
Carbonate of lime,	33.92
No Magnesia.	
	100.90

This will much assist the general description in conveying an idea of the nature of these rocks.

The dip all through is a few degrees west of north, at angles varying from 10° to 25°; with an average of 18°, the section of 500 feet

long gives at the north end a thickness (supposing the lower beds not to thin out) of 155 feet, and a depth of 159 feet. This does not give a correct idea of the general thickness of the Devonian rocks; thus, in Newbridge demesne, the red conglomerate alone shows for a *horizontal* distance of over 1000 feet;—to continue the section, for the next 400 feet there is no rock seen; we then come upon a low, flat, anticlinal of red and yellowish sandstones, some of them coarse and brecciated; these are seen for about 170 feet; there is then another break for 150 feet, when we come upon a confused appearance, for 140 feet, of hard, red sandstone, a fine breccia of slate and quartz, in a red and gray calcareous paste, and uppermost, a bed of hard siliceous limestone, and one of fine gray marl; the average dip is 20° to N. 20° W.; for the next 200 feet there is no rock *in situ;* then the greenstone. I have given the railway section rather in detail, as it is the clue to the position of the newer rocks.

It is through the first of these short sections that the boundary has been drawn, ranking the upper beds as lower mountain limestone, and the lower ones as 'old red' or Devonian. I have not been able to discover sufficient reason for making here so decided a division; certainly the lower beds are red, and the top ones blue or near it: but even lithologically, there is less difference between the lower arenaceous and the upper calcareo-argillaceous portion of this series than between the latter and the clear blue crystalline beds of the 'lower limestone' group, as seen in the neighbourhood. I think I can by fossils strengthen this relationship. In some of the lower beds of the earthy nodular limestone above mentioned I have found delicate carbonaceous impressions of land plants. Would not this separate these beds more distinctly from the essentially marine deposits of the mountain limestone, which, as seen in this vicinity, chiefly abound in the remains of corallines, crinoids, and palliobranchiate molluscs, uniting them at the same time to the essentially littoral or shallow water-beds, of purely mechanical origin, upon which they rest? I cannot undertake to say what special Fauna the fossils I have found most resemble. I have used them merely as marks; physical impressions would, for the use I have made of these, answer as well as physiological impressions, or as organic remains. In the same bed with the plants I got a *Byssoarca*, M'Coy (*B. lanceolata*); also, an orbicula, very flat, with broad,

deeply-marked, slightly eccentric rings, and a faint impression of what I take to be a fish scale; in an associated, hard, compact bed, a pecten, a modiola (?), and a small orthoceras.

The opinion that these calcareous beds were superior to all the arenaceous beds in the cutting, and their apparent dip under the red sandstones to the north of them, must have been the reasons for putting a fault between, with a downthrow to the south. I hold to the same order of superposition, and dispense with the fault: there may be a slight one, but I had rather not assert it; the conglomerate and greenstone at the base of the section, only 700 feet south of where the fault would be, are at the same level as the other conglomerate and greenstone of the district; there is, moreover, ample room for the beds to come up again between the point of their disappearance and the next rock. This view is confirmed by the fact of this rock being a flat anticlinal of red and yellowish sandstone, which may be the highest sandstone beds of the section to the south,—thus requiring space for only about 50 feet thick of calcareous beds. The bed of limestone and of marl, on the extreme north of the stratified portion of the railway section, I consider an outlier of the beds on the south: it is too insignificant to be noticed on the map. All these strata seem to have been deposited in a trough or basin, against the sides of greenstone, probably on a bottom of contorted Silurians. At the edges we have the coarse arenaceous rocks; in the centre, the calcareo-argillaceous; or, more likely still, these finer beds once overlapped all the lower ones. It is easy to imagine how, in the many elevations, depressions, and other vicissitudes they have gone through, they may have been crushed and shifted into their present position. (See Sect. 2, p. 276.)

To the north of Newbridge demesne, on the road side, there is a quarry of flaggy, earthy limestone, with some hard cherty beds: they dip at about 15° to N. 15° W.: they are only 1100 feet distant from the conglomerate in the demesne, and have altogether the same relation to it, as the upper beds in the railway cutting bear to the conglomerate south of them. Lithologically, they are very similar to these upper beds, and I think they are identified by their fossil contents. In some of the earthy layers I found plant impressions, quite the same as I got before on the railway. If these plant-bearing beds are to be classed with either the rocks above or below them, I would be in favour of the latter: there is no unconfor-

mability, no sudden change of texture, or even of colour: on the contrary, everything is gradual, and the conditions of formation of even the extremes need not have been very dissimilar; no extraordinary circumstances are necessary to account for the red conglomerate,—as coarse a one might be formed in a small lake; and the upper calcareous beds have many indications of the proximity of land.

In the overlying mountain limestone we have a great extent, vertical or horizontal, of a very different type of rock. The transition is not discoverable; the few facts we can collect are in favour of its being a gradual one. There are but three spots where the lower limestone can be well seen: on the southern shore, immediately to the east of the railway, there is a quarry of hard, blue limestone, in thick, regular beds, with an occasional parting of dark indurated shale; they dip N. 30° W. at about 15°, and as one of the greenstone masses is but ten yards north of them, they must have got into their present position by sliding down along a fault. Near the shore, on the north, a little to the west of the railway, there is a small quarry of strong beds of crinoidal limestone, dipping N. at 20°. On the extreme west, just by the side of the coach-road, there are two quarries of clear crystalline limestone, with dark shales, dipping N. 10° W. at 25°. There can be little doubt that these beds once covered all the rocks we have been describing. The whole series seems to indicate a slow, continued subsidence, possibly from a state of Silurian land to that of an open ocean; but such general conclusions, from the examination of so limited a district, are of little worth.

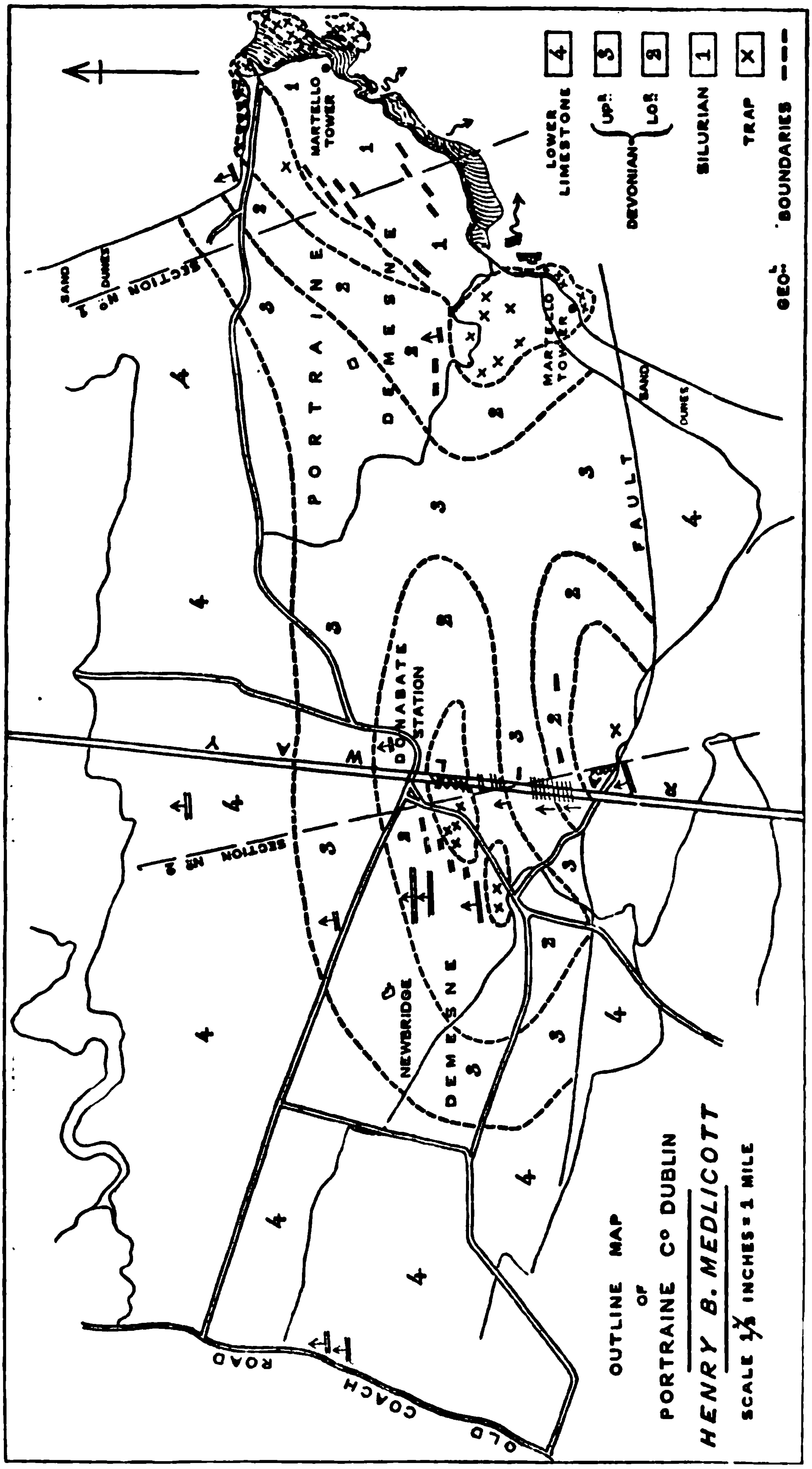
However palæontologists decide upon the fossil contents of the beds in the railway cutting, it does not alter their relation to the red arenaceous beds on which they rest. Considering these last as belonging to the old red or Devonian formation, I have separated the upper beds from the lower limestone group, with which they have been hitherto placed, and given them a separate colour, as upper Devonian; I suppose them to occur in a band round the red sandstones, and to be in turn lost under the mountain limestone. Apart from the unimportant and merely nominal distinction of belonging to the upper Devonian or lowermost carboniferous, this will establish them as intermediate between the more decided types of these two great palæozoic formations.

I have not feared, for the inspection of geologists, to draw in boldly the boundaries of the groups between the eastern and middle portion of the district: this space is very low, and deeply covered with drift. There are several possible, and almost equally probable, plans for the outcrop of the rock beneath. There may be greenstone or red sandstone the whole way across; Silurian beds may appear, or, less likely, there may be a tongue of lower limestone. Farming or other operations may put it in the power of some future explorer to settle this question.

The lower limestone in this part of the country occurs in great waves, striking E. and W. Owing to some cause in the latest denudation of the drift, the accumulation has been more on the southern slope of these ridges; hence quarries are opened on the northern, and, consequently, the registered dips are northerly.

The geological description of the island of Lambay ought not to be separated from that of Portraine. The same rocks occur in each, and each would probably assist much in the study of the other. Although only three miles from shore, the difficulty of getting there is such that I did not even make the attempt.

On the outline Map I have made of the district, I have only marked the carriage-roads, water-courses, and principal demesne boundaries. Wherever rock is seen *in situ*, there are parallel strokes in the direction of the strike for the sedimentary rocks, and a small cross for the igneous. The sections are not strictly plotted in any single line, but are compiled so as to represent all the phenomena of the district; they are on a much larger scale than the Map.



OUTLINE MAP
OF
PORTRAINE Cº DUBLIN
HENRY B. MEDLICOTT
SCALE 1⅓ INCHES = 1 MILE
LOWER LIMESTONE 4
DEVONIAN UPR. 3
LOR. 2
SILURIAN 1
TRAP X
GEOL. BOUNDARIES
PORTRAINE DEMESNE
NEWBRIDGE DEMESNE
DONABATE STATION
MARTELLO TOWER
MARTELLO TOWER
SAND DUNES
SAND DUNES
SECTION No 1
SECTION No 2
FAULT
RAILWAY
OLD COACH ROAD

Section No. 1.—PORTRAINE DEMESNE AND COAST.

Section No. 2.—NEWBRIDGE DEMESNE AND RAILWAY CUTTING.

June 8th, 1858.—"Notes on the Geology of Egypt;" by LORD TALBOT DE MALAHIDE.

IT is singular how little has been done to investigate the geology of Egypt, with the exception of a few mining adventurers, who have been employed by the Pachas in seeking for gold and silver, emeralds, and other precious substances. We are almost dependent on the information contained in the valuable paper of Lieutenant Newbold, read to the London Geological Society on the 29th June, 1842.

It would appear that but few distinct geological formations are represented within its area. The anticlinal axis between the Nile and the Red Sea is chiefly composed of granite, porphyry, and trap rocks, cut through by veins, dykes, and overlaid, in the latitude of Kosseir and Thebes, by the beautiful *breccia verde*.

Whether the section is taken from S. to N. or from E. to W. is nearly the same thing. Next to the crystalline and metamorphic rocks comes a gray sandstone, which, as it is good freestone, was quarried to a great extent at Gebel Silsili by the ancient Egyptians, and is one of the stones most used in the ancient buildings throughout the country. The statues of the Memnon are formed of it. It extends for a great distance to the south of the first cataract, and I believe is found at several intervals along the upper course of the Nile, where the granite and other volcanic rocks do not emerge to the surface.*

Next to the sandstone is a very deep bed of marine limestone. This extends about four degrees of latitude from the vicinity of Esneh to Cairo. It may be divided into two well-marked divisions.

* The most remarkable locality, Gebel Silsili, is thus described in a journal which I kept during my travels in Egypt in the year 1839:—

"The quarries of Gebel Silsili appear to be very regularly and economically worked. The use of the chisel is very evident, and in many places the marks of wedges are visible. The stone appears to vary much in hardness and colour. It is horizontally bedded in thick strata, contains frequent nodules of iron, and occasionally veins of this ore, small seams of calcareous matter, but no organic remains. From the broken appearance of the surface in many places, the large masses scattered about the small ravines extending towards the Nile, and numerous pebbles of quartz and other crystalline rocks, it is evident that currents, or diluvial action, have at one time taken place far above the level of the Nile. I found a small bit of petrified wood on the hills, and also a petrified bone on the shore near the river. Hajar Silsili is an isolated rock, nearly undermined, and strongly resembling the Tors of Dartmoor."

The lower one resembles an indurated chalk, is of a dazzling white colour, and is full of cherty nodules, and a few shells of a large size,—hippurites, echinites, nautili, &c. The upper division seems to be almost a select mass of nummulites: it is of a cream colour, and very often and easily affected by the atmosphere. The great Sphynx and a large proportion of the materials of the great Pyramids are composed of this rock. The harder stratum forms the rocky cliffs of Babel Melouk, at Thebes, and the quarries of Toura, near Cairo, in the east bank, which, from the cartouches carved on the near surface, appear to have been worked from the remotest antiquity, are of the same stone. It is a very good material for carving gigantic figures, and resists better than the sandstone the caustic effects of the magnesia in the sand of the desert. The figure of Rameses II., now half-buried at Mitrahenny, the ancient Memphis, is of this material.* The Egyptian jasper, a very beautiful stone for the lapidary, is found in small nodules imbedded in the limestone on the banks of the Nile, near the island of Philæ. Numerous pebbles of this jasper are found, and the poor labourers traffic largely in them with European travellers.

Above the limestone there is another sandstone, which extends for a considerable distance on the road from Cairo to Suez, and is chiefly remarkable for containing numerous stems of silicified trees, so much so as to give the appearance of a petrified forest.

In the immediate vicinity of Cairo, Gebel Ahmar, in this formation, gives quite the appearance of a small volcano. The form of the ground would support this hypothesis, and the blood-red colour and porous character of the stone would deceive many a superficial observer, and make him suppose that he saw some of the porous kinds of Vesuvian lava. There are fossils found in this stratum, but I have not seen any catalogue of them.†

* The rocks in which the tombs of the Kings at Thebes are excavated are composed of limestone of a very compact character—sometimes *breccia*, sometimes interstratified with shale, and containing nodules of flint in nearly horizontal strata. They are generally globular, and I could not find any trace of any organic substance in the interior. The limestone, however, contains some bivalve shells, and the rock appears quite different in mineralogical character from that of Lower Egypt as far as Beni Hassan. A considerable part of the road is strewn with flints, as on our own downs.

† Rode to the Red Mountain.—The nucleus consists of sandstone, which varies both in hardness and fineness of grain from a pale white to a brick-red colour. It

The most interesting question connected with the geology of Egypt is the age of the great fossiliferous limestone stratum. I believe there is no doubt that it is of the same age as an immense tract extending through Northern Europe to Asia Minor, and from thence to Persia and India. Great difference of opinion has prevailed as to this formation. Continental geologists have generally considered it to belong to the cretaceous system. (See Boué Géologue Voyageur.) It appears, however, to me that Sir R. Murchison, in his elaborate paper on the structure of the Alps, has set the matter at rest, and proved, both stratigraphically and by a discussion of its fossils, that it belongs to the eocene or oldest tertiary series. I produce a few fossils found by myself on the spot—some belonging to the upper part of the bed, and others from the lower stratum near Thebes. I also produce some specimens of the secondary rocks. The granites, basalts, porphyries, &c., are too well known to naturalists to require illustration.

"Geological and Statistical Notes on Irish Mines;" by the Rev. Samuel Haughton, Professor of Geology in Trinity College.

No. I.—Ballymurtagh Sulphur and Copper Mine.

The Ballymurtagh sulphur and copper mine is the most westerly of a group of mines, worked on a series of parallel lodes or veins, at both sides of the Ovoca, in the county of Wicklow. The average strike of these lodes is north of east and south of west; in Ballymurtagh itself it is E. N. E. (true bearings), with an underlay south, varying from 50° to 70°. A line of fault appears to separate the mines on the west of the Ovoca from those on the east; the direction of the heave being left-handed, throwing the mines on the west bank of the Ovoca to the south.

The rock of the country is lower Silurian slate, which is gene-

is sometimes very fine, and at other times assumes the character of a decided conglomerate, with flints and chalcedonies imbedded in it. This last quality is the rarest, and generally assumes an irregular appearance of veins. They are slightly inclined from the horizontal line, and appear to me the surest indication of the stratification. There is no appearance of fossils. It has been quarried to an immense extent, and is so still. This mountain is nearly insulated, and the tertiary limestone of G. Mokattem is to be traced in close contact on its flanks.

rally, in the neighbourhood of the mines, of a dark colour, from the presence of hornblende, and frequently assumes the green colour and greasy feel of talcose slate. The Bell Rock, to the south of the mine, is a gray quartz rock, almost infusible, but containing small particles of a dark mineral, which fuse when exposed to a considerable heat. This rock is bedded conformably with the slate, and appears to have undergone considerable metamorphic action, although it is difficult to imagine that it was ever fluxed.

Quartz spar, as might be expected, is of common occurrence in the mine, particularly in the lode called the "Spar Vein." (*Vide* section, p. 282.)

I have found also in the lower levels of the copper lode, carbonate of lime, containing a considerable quantity of magnesia. This occurs in the green greasy slate.

The mines of this district, reckoned from west to east, are,—Ballymurtagh and Ballygahan, on the west of the Ovoca; and Tigroney, Cronebane, and Connorree, on the east. Indications of pyrites exist at each extremity of this mineral district, but not in sufficient quantity to pay for working.

The minerals raised at Ballymurtagh are iron and copper pyrites, which are mixed together in very variable proportions; the quantity of copper pyrites generally increasing as the mine is worked in depth.* The pyrites does not appear to occur in a regular lode or vein with definite walls, but to be diffused through the slate which forms the country in beds, which are stratified conformably with the slate itself; it does not occur pure, but intimately mixed with the slate; the iron pyrites occurs in greatest abundance near the surface of the lode or bed, which becomes richer in copper pyrites as the mine increases in depth.

There are at present five lodes or beds worked on the Ballymurtagh mine, parallel to each other, and conformable to the bedding of the hornblende slate and quartz rock of the district.

These lodes, reckoned from the southern extremity of the townland, are—

1st. The South, or Copper Lode.

2nd. The Pyrites Lode.

* Sulphuret of zinc or blende is also occasionally found to occur in large masses, combined in a remarkable manner with sulphurets of lead and iron.—*Vide* Dr. Apjohn's description, Journal, vol. v., p. 184.

3rd. The Pond Lode.

4th. The North Mine, South Lode.

5th. The North Mine, North Lode.

The first two of these constitute the old mine; the latter are recently discovered lodes, which were not worked until the mine became the property of the Wicklow Copper-Mine Company.

The second, or pyrites lode, joins the first, or copper lode, at about the 56 fathom level, below which there is only one lode, which is worked to a depth of 160 fathoms, the lower part being particularly rich in copper.

The north lode (No. 5) is principally worked for iron pyrites, but occasionally considerable quantities of copper pyrites are found in it; recently a quantity of native copper, 28 lbs. in weight, was found in this mine.

The back of this lode is characterized by a remarkable bed of brown hæmatite, which lies upon the bed of iron pyrites.

A careful analysis of an average specimen of this hæmatite, made by the Rev. Joseph A. Galbraith, gave—

Peroxide of iron,	74·37
Clay and Silica,	11·00
Water,	14·12
Volatile Matter,	0·41
Loss,	0·10
	100·00

The metallic iron in this ore amounts to 52 per cent.; and as it is free from phosphoric acid and sulphur, it is a valuable ore. At the present price of, and demand for iron, this ore would be worth from fifteen to seventeen shillings per ton in South Wales.

No. 1. The copper, or south lode, has been worked extensively from near the surface over an extent of about 200 fathoms long, and down to the 110 fathom level, about 150 fathoms deep.

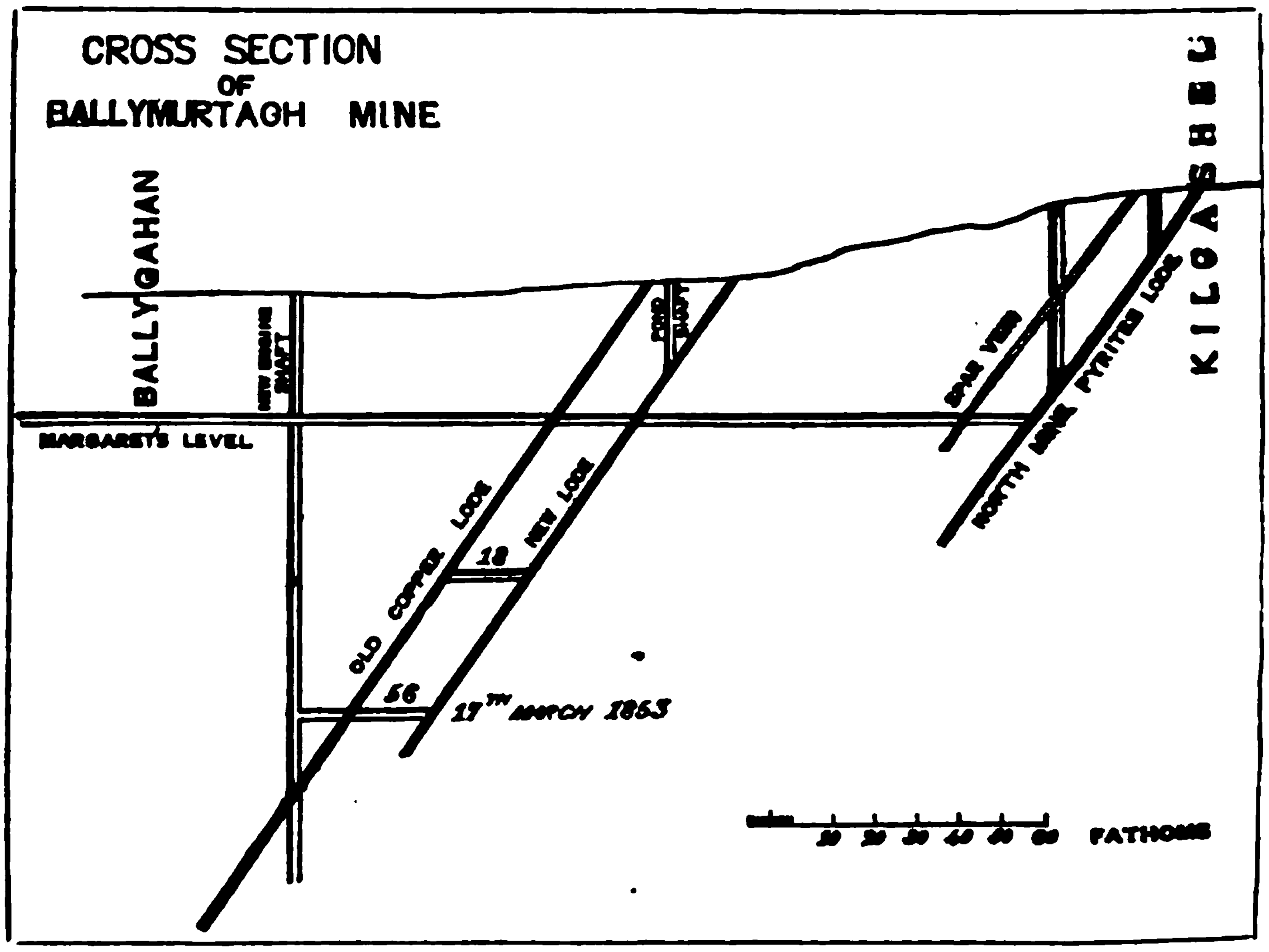
No. 2. The north pyrites lode is opened to 60 fathoms deep, and extended about 70 fathoms.

No. 3. The south lode, north mine, is opened to 30 fathoms deep, and extended 40 fathoms.

No. 4. The pond lode is opened 110 fathoms deep, and extended as under:—

At Margaret's level,	60 fathoms.
At 18 fathom level from north cross-cut,	40 „
At 56 fathom level from north cross-cut,	8 „

About twelve months ago all these lodes were proved in depth by the driving of Margaret's level, which is represented in the annexed section; and still more recently the pond lode has been proved



by cross-cuts from the south mine, at the 18 and 56 fathom levels. This lode has been found, like all the other lodes in Ballymurtagh, to become richer in copper in depth. In driving Margaret's level, a spar vein, 70 feet thick, was cut to the south of the north pyrites lode. This spar was composed of sugary quartz, presenting the vughy appearance which is considered by working miners so valuable as an indication of a mineral lode underneath. The iron pyrites generally occurs in all the lodes near the surface, to the depth of about 50 fathoms, varying in width from 4 to 36 feet, and in hardness and quality in proportion as the ore is mixed with ribs of copper pyrites, or the slate or killas of the country. It contains from 35 to 40 per cent. of sulphur, capable of being used for the manufacture of sulphuric acid: it was proposed as a substitute for brimstone in 1839, in consequence of the high price of that article, occasioned by the greediness of the Neapolitan Government, who had a practical monopoly of the sulphur trade by the possession of the Sicilian sulphur beds.

The first cargo of pyrites, as a substitute for Sicilian sulphur, was sent by the Wicklow Copper-Mine Company on the 28th December, 1839, to Messrs. Newton, Keats, and Co., of Liverpool, the price received for this cargo being 37*s.* per ton of 21 cwt., free on board, the reported produce being 40 per cent. of sulphur, and 1¼ per cent. of copper. The experiment thus tried proved eminently successful, as is shown by the third and fourth columns of the Table, p. 284.

To understand this Table, it should be observed that the ore raised in Ballymurtagh is divided for sale into three classes:

1. Pyrites or Sulphur Ore.
2. Coppery Pyrites.
3. Copper Ore.

1. The sulphur ore contains, on the average, 35 per cent. of sulphur, capable of being extracted.

2. The sulphur copper ores are divided into two classes, the poorer containing about 1¼ per cent. copper, and the richer about 3 to 4; both these classes contain 35 per cent. of sulphur, and are sold to the acid manufacturers, who allow a price for the copper, and send the ore, after being roasted for sulphur, to the Swansea ticketings.

3. The copper ores contain from 3 to 10 per cent. of copper, and are sent direct to Swansea from the mine.

The third and fourth columns contain the total quantities of sulphur ore raised and sold by the Ballymurtagh mine from 1840 to 1852. In 1840 the price at which pyrites could be delivered in England was about 30*s.* to 35*s.* per ton; the corresponding price of brimstone being £12 per ton. Previous to the monopoly in sulphur, the price, taking the average for fifteen years, was £7 per ton. The present price of pyrites is from 20*s.* to 21*s.* per ton, and of brimstone about £6. The capability of the Wicklow mines for producing pyrites is very great, the shipments while the demand lasted in 1841 having been nearly 100,000 tons, producing 40,000 tons of sulphur.

The pyrites vein, or "sulphur course," is what miners call the parent vein or matrix of the lode; it continues, mixed with the copper pyrites, down to the very bottom of the mine, where the copper sometimes reaches 10 per cent. of the ore, and in the shallow work-

ings copper is never totally absent, being generally $\frac{1}{4}$ per cent. even of the pure pyrites lode.

The water issuing from the pyrites workings is strongly impregnated with copper, and on being passed over plates of iron yields a precipitate containing from 10 to 30 per cent. of copper.

An Account *of Ores raised at Ballymurtagh Mine in the following Years:—*

Year ending March	Copper Ore.	Coppery Pyrites.	Pyrites.	Total each year.
	Tons.	Tons.	Tons.	
1834	2821	"	"	2821
1835	5094	"	"	5094
1836	4569	"	"	4569
1837	5666	"	"	5666
1838	6457	"	"	6457
1839	4980	"	"	4980
1840	6706	"	500	7206
1841	3300	"	16428	19728
1842	4779	"	14793	19572
1843	4540	"	11795	16335
1844	5180	"	8363	13543
1845	5056	"	15196	20252
1846	4738	1500	11453	17691
1847	3660	3000	12170	18830
1848	3054	3707	12014	18775
1849	3613	4000	9300	16913
1850	3757	4000	10497	18254
1851	2032	4000	19802	25834
1852	2233	4058	24472	30763
Tons,	82235	24265	166778	273278
Add raisings half year ending September, 1852,	1150	2000	12700	15850
Tons,	83385	26265	179478	289128

The quantity of copper ore raised in the twelve years ending 31st December, 1858, was about 25,000 tons.

As no records or maps exist of the former working of this mine, the early history of it is involved in difficulty,—as all the knowledge

now possessed of the workings previous to 1822 is founded on the verbal statements of old persons, and such data as have been obtained from time to time from the Messrs. Camac and Kyan's accounts.

The Ballymurtagh mine, about eighty-five years ago, was worked by Mr. Whaley, who is said to have made a large fortune from the copper ore raised on the south lode, at depths hardly exceeding 40 fathoms. These old workings, which have been since partially explored, show evident traces of rich branches of ore having been taken away, and subsequently by the application of tutwork and better means of bringing the ore to grass, large quantities of copper ore, of about $7\frac{1}{2}$ produce, were obtained from these old places. Mr. Whaley, besides the advantage of shallow depth, had labour of the cheapest kind, and very high market prices for his ores.

In the year 1780 the workings were resumed by the Hibernian Mine Company, being then about 45 fathoms deep, and drained by an expensive and uncertain system of hand pumps. This Company expended a large capital in more fully opening the lodes, operated largely on the copper as well as the sulphur lodes, when the latter contained a portion of copper, and after erecting calcining and smelting works, making vitriol and precipitate copper, were finally obliged to abandon the concern, after sustaining a large pecuniary loss, about the year 1800.

The mine then lay idle, or nearly so, until 1822, when it was undertaken by a few private individuals, who subsequently formed the Wicklow Copper-Mine Company. During the next ten years the results were uncertain and unsatisfactory, much difficulty arising from the ruinous state in which the mine was left by the Hibernian Mine Company, the continuance of inefficient pumping and drawing machinery, or rather the nearly total want of them. These and other causes retarded the efficient prosecution of the works until the year 1832, since which period the mine has been very successful.

I cannot conclude this short account of Ballymurtagh mine without expressing my obligations to Mr. Edward Barnes, Mining Agent of the Wicklow Copper Mine Company, to whom I am indebted for the information relating to the present state and former working of the mine.

APPENDIX.

TITLES OF PAPERS

READ BEFORE

THE GEOLOGICAL SOCIETY OF DUBLIN.

FROM THE MINUTE BOOKS OF THE SOCIETY.

No. of Paper.	Paper.	Author.	When read.	Page of Minute Book.	Observations.
	Session, 1831–2.				
1	Address delivered at First Annual Meeting of Geological Society,	Rev. Bartholomew Lloyd,	February 8, 1832. .	3	Journal, vol. i. p. i.
2	On Globular Formations, ...	Whitley Stokes, M. D.,	March 14, 1832. .	4	
3	On the occurrence of Peat beneath certain parts of the City of Dublin,	Philip Molloy, Esq., .	April 11, 1832. . .	5	
4	On the Study of Geology in Ireland, ...	Captain Portlock, . .	April 11, 1832. . .	5	Journal, vol. i. p. 1.
5	On the Fo	John Hart, M. D., . .	April 11, 1832. . .	5	Journal, vol. i. p. 20.
6	On the C occur in the Beds a re,	Captain Portlock, . .	June 13, 1832. . .	6	See Journal, vol. i. p. 60.
	Session, 1832–3.				
7	On the Conglomerate near the Beach at Kingstown,	Philip Molloy, Esq., .	November 22, 1832.	6	MS. in Library.
8	On the Basaltic District of the North of Ireland,	Captain Portlock, . .	November 22, 1832.	6	Journal, vol. i. p. 71.
9	On the Trap Formation of the County of Limerick,	James Apjohn, M. D., .	December 12, 1832.	7	Journal, vol. i. p. 24.
10	Address delivered at Second Annual Meeting of Geological Society,	Rev. Bartholomew Lloyd,	February 13, 1833.	8	Journal, vol. i. p. 58.
11	On the Identification of Strata, ...	Captain Portlock, . .	March 13, 1833. .	8	Journal, vol. i. p. 75.
12	On Globular Formations (corrected and enlarged, etc	Whitley Stokes, M. D.,	April 10, 1833. . .	9	Journal, vol. i. p. 15. (Jour-
13	On the Evidences of Diluvial Action in the North of Ireland, with Notes by Captain Portlock, and Mr. Bryce's	James Bryce, Esq., . .	April 10, 1833. . .	9	MS. has
14	On the Geology of Erris, Cou	P. Knight, Esq., . . .	May 8, 1833. . .	10	MS. rary.
15	On the peculiar Porphyry of parts of the County of Antrim,	Lieutenant Stothard, .	May 8, 1833. . .	10	10,

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
16	On a Dyke traversing the County of Tyrone, .	Lieutenant Fenwick, .	May 8, 1833. . .	10	See Third Address, p. 10, which has "3rd May."
17	Notes, by a brother Officer, on the Penetration of Mica Slate by Veins of Trap,	Captain Portlock, . .	June 12, 1833. . .	11	
	Session, 1833–4.				
18	On remarkable Boulders of Granite, exposed in the Cuttings of the Dublin and Kingstown Railway,	Rev. Humphrey Lloyd,	November 13, 1833.	12	Journal, vol. i. p. 83.
19	On the Locality of the Fossil Deer, recently discovered in the County of Wexford,	James M'Cartney, M. D.,	November 13, 1833.	12	
20	On the Rocks in the vicinity of Bonmahon, and of the Conglomerate Formation of the County of Waterford,	J. H. Holdsworth, Esq.,	November 13, 1833.	12	Journal, vol. i. p. 85.
21	On the Geology of the District of the Alten Mines, in Finmark,	John Petherick, Esq., .	December 11, 1833.	12	Journal, vol. i. p. 66.
22	Further Account of the Limerick Trap Rocks, .	W. Ainsworth, Esq., .	January 8, 1834. .	13	Journal, vol. i. p. 112. See No. 9. (Journal has "Dec. 11, 1833.")
23	On a Granite Vein traversing Mica Slate, on the Coast of Wicklow,	Robert Graves, M. D., .	January 8, 1834. .	13	Journal, vol. i. p. 69.
24	On a Fossil Plant found on the shore near Carrickfergus,	J. T. Mackay, Esq., .	January 8, 1834. .	13	Journal, vol. i. p. 79.
25	Address delivered at Third Annual Meeting of Geological Society,	Rev. Bartholomew Lloyd,	February 13, 1834.	15	Journal, vol. i.
26	On the Mitchelstown Cave, ...	James Apjohn, M. D., .	March 12, 1834. .	15	Journal, vol. i. p. 103.
27	On a recent Landslip near Larne, ...	James M'Adam, Esq., .	March 12, 1834. .	16	Journal, vol. i. p. 100. MS. of Mr. Hutton's Report on Nos. 26 and 27 in Library.

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
28	On the Geological Features of the Peninsula of Fannet, County of Donegal,	James M'Adam, Esq., .	April 9, 1834. . .	16	Journal, vol. i. p. 128. Part of MS. in Library.
29	On an Instrument denominated by him an "Orthoscope,"	Archdeacon Verschoyle,	May 14, 1834. . .	17	MS. in Library.
30	On a Granite Vein in the vicinity of Killiney, .	Rev. Sidney Smith, . .	May 14, 1834. . .	17	
31	On the Bay of Dundalk, ...	Captain Portlock, . .	May 14, 1834. . .	17	Journal, vol. i. p. 246.
32	On Meteorites, ...	Whitley Stokes, M. D.,	June 11, 1834. . .	18	
	Session, 1834–5.				
33	On the Discovery of Granite in the County of Cavan,	Captain Portlock, . .	November 12, 1834.	18	MS. in Library.
34	On the Portrush Rocks, ...	James Bryce, Esq., . .	December 10, 1834.	19	Journal, vol. i. p. 166.
35	On the Elephant's Remains found at Artane, .	Rev. Sidney Smith, . .	December 10, 1834.	19	MS. in Library.
36	On the Bay of Dundalk, ...	Captain Portlock, . .	January 14, 1835. .	20	
37	On a Limestone District north-east of Carlingford,	Major Patrickson, . .	January 14, 1835. .	20	Journal, vol. i. p. 180.
38	On the Mourne Mountains, ...	Lieutenant James, . .	January 14, 1835. .	20	For this and the last Paper, Address (p. 20) has "15th January."
39	Address delivered at Fourth Annual Meeting of Geological Society.	Richard Griffith, Esq., .	February 11, 1835.	22	Journal, vol. i.
40	On the Action of Trap Dykes on Chalk and Sandstone,	James Bryce, Esq., . .	March 11, 1835. .	23	MS. in Library.
41	On the occurrence of Marine Shells, identical with those now existing on the Shore of Dundalk Bay, in Gravel and Sand, which forms the Substratum of a low part of the Country around and under Dundalk,	Captain Portlock, . .	March 11, 1835. .	23	

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
42	On the stone of Hollywood, and its a	James Bryce, Esq., . .	April 8, 1835. . .	24	Journal, vol. i. p. 175.
43	On the Quartz Rock of Howth, ...	John Scouler, M. D., .	May 13, 1835. . .	24	
44	On the Fossils which occur in the Limestone of Kildare,	Rev. Sidney Smith, . .	June 10, 1835. . .	26	
45	O arish of a Gray- surfaces of which, wherever in contact with the water, are encrusted with Calcareous Spar,	Captain Portlock, . .	June 10, 1835. . .	26	
	Session, 1835–6.				
46	Account of the Proceedings of the Geological Section of the great Meeting of Philosophers, recently held at Bonn, on the Rhine,	Rev. Sidney Smith, . .	November 11, 1835.	27	
47	On the relative Ages of the Crystalline Rocks of the County of Antrim,	Richard Griffith, Esq., .	December 9, 1835. .	27	
48	On some Fossil Fish discovered by him near Dungannon, County of Tyrone,	Captain Portlock, . .	December 9, 1835. .	27	
49	On the Trap District of the County of Limerick,	John Scouler, M. D., .	January 13, 1836. .	28	Journal, vol. i. p. 135.
50	Address delivered at Fifth Annual Meeting of Geological Society,	Richard Griffith, Esq., .	February 10, 1836.	30	Journal, vol. i. p. 141.
51	On the Position of the Gold Mines in Brazil, .	F. J. Warre, Esq., . .	March 9, 1836. . .	30	
52	Abstract of his Paper. in Silliman's Journal of Science, o of the Coal 1	—— Hildreth, Esq., .	March 9, 1836. . .	30	
53	Verbal Account of the occurrence of Recent Shells in Beds of Alluvium in the vicinity of Dublin,	John Scouler, M. D., .	April 13, 1836. . .	32	

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
54	On the Mud Volcanoes of Trinidad, ...	Thomas D. Brooke, Esq.,	April 18, 1836. . .	32	MS. in Library.
55	On the occurrence of Marine Shells, corresponding to those of the present seas, at high elevations in the County of Sligo. (Observed by G. Townsend, Esq., about 200 feet above the level of the sea),	Captain Portlock, . .	April 18, 1836. . .	32	MS. in Library; interesting.
56	On Chambered Shells, ...	John Scouler, M. D., .	May 11, 1836. . .	33	
57	On the occurrence of an Insulated Formation of Granite in the County of Cavan, with a Note by Captain Portlock on the same subject,	Lieutenant Stotherd, .	May 11, 1836. . .	33	MS. in Library.
58	On the Connexion between Mineralogy and Optics,	Rev. Humphrey Lloyd,	June 8, 1836. . .	34	Journal, vol. i. p. 210.
	Session, 1836–7.				
59	On the Cervus Megaceros, or Fossil Elk, . .	John Scouler, M. D., .	November 9, 1836.	34	Journal, vol. i. p. 197.
60	Summary of Ehrenberg's Views, which establish a new Coincidence between the State of Nature at remote and in existing Periods,	Sir Robert Kane, M. D.,	November 9, 1836.	36	
61	On Animals which have disappeared from Ireland during the period of authentic history,	John Scouler, M. D., .	December 14, 1836.	37	Journal, vol. i. p. 224.
62	On a Tufaceous Production found near Downpatrick, on the Coast of Mayo,	Captain Portlock, . .	December 14, 1836.	37	
63	On Granite Pebbles found in the Detritus at the base of some of the Tipperary Mountains,	James Apjohn, M. D., .	January 11, 1837. .	38	
64	On the Silicified Wood of Lough Neagh, . .	John Scouler, M. D., .	January 11, 1837. .	38	Journal, vol. i. p. 231.
65	Address delivered at Sixth Annual Meeting of Geological Society,	Colonel Colby, . . .	February 15, 1837.	40	Journal, vol. i.

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
66	On a Deposit of Calcareous Tufa in the Queen's County,	C. W. Hamilton, Esq., .	March 8, 1837. . .	41	
67	On the Sources of Carbonate of Lime as a Cement in concretionary masses,	Captain Portlock, . .	March 8, 1837. . .	41	
68	containing Oxide of Copper, from Sweden,	Professor Davy, . . .	April 12, 1837. . .	42	Journal, vol. i. p. 241.
69	On the Uniformity observable in the older Rocks,	Captain Portlock, . .	April 12, 1837. . .	42	
70	On some remarkable Rocks of the County of Antrim,	Captain Portlock, . .	May 10, 1837. . .	43	
71	On the Limestone of the County of Wexford, and its Geological Relations,	C. W. Hamilton, Esq., .	June 14, 1837. . .	44	Journal, vol. i. p. 313.
	Session, 1837–8.				
72	On the Stratification of the Penrhyn Quarry, North Wales,	C. W. Hamilton, Esq., .	November 8, 1837.	45	
73	Description of Fossils from the Himalaya Mountains,	Thomas Beatty, M. D.,	November 8, 1837.	45	
74	On the Action of Igneous Rocks, ...	Captain Portlock, . .	December 13, 1837.	46	
75	On the Geology of the Dingle District, . . .	C. W. Hamilton, Esq., .	December 13, 1837.	46	
76	On the Mechanism of the Motion of Glaciers, .	Robert Mallet, Esq., .	January 10, 1838. .	47	Journal, vol. i. p. 317. MS. in Library, with Dr. Lloyd's Report.
77	On the elevated Beds of Gravel, containing Shells, in the Vicinity of Dublin,	John Scouler, M. D., .	January 10, 1838. .	47	Journal, vol. i. p. 266.
78	Observations on the Hills called "Eskars," .	Arthur Jacob, M. D., .	January 10, 1838. .	47	
79	Address delivered at Seventh Annual Meeting of Geological Society,	Captain Portlock, . .	February 14, 1838.	49	Journal, vol. i. p. 249. (Journal has "Sixth.")

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
80	On the Origin of Dolomites, ...	John Scouler, M. D., .	March 14, 1838. .	49	Journal, vol. i. p. 382.
81	On the Diluvial or Northern Drift of the eastern and western sides of the Cambrian Chain, and on its connexion with a similar deposit on the eastern coast of Ireland,	Joshua Trimmer, Esq., .	April 11, 1838. . .	51	Journal, vol. i. p. 286.
82	On the Analysis of certain Irish Dolomites, and of a [illegible] Chalk, altered by conta[illegible] ap,	James Apjohn, M. D., .	May 9, 1838. . .	51	Journal, vol. i. p. 368.
83	On Chr[illegible] in the County of Mayo,	—— Smith, ...	May 9, 1838. . .	51	
84	On the Diluvial or Northern Drift of the eastern and western sides of the Cambrian Chain, and on its connexion with a similar deposit on the eastern coast of Ireland (in continuation),	Joshua Trimmer, Esq., .	June 12, 1838. . .	52	Journal, vol. i. p. 385.
	Session, 1838–9.				
85	[illegible] Session, . . .	Richard Griffith, Esq., .	November 14, 1838.	53	Journal, vol. ii. p. 35.
86	[illegible] a Conglomerate [illegible] r the Church of [illegible] vonshire, by the contact of a mass of Trap,	Joshua Trimmer, Esq., .	November 14, 1838.	53	
87	On the Euomphalus, ...	Daniel Dowling, Esq., .	November 14, 1838.	54	
88	On the Working of the Newcastle Coal-field, .	Robert Mallet, Esq., .	December 12, 1838.	55	
89	On the Junction of Granite and Mica Slate at Killiney,	John Scouler, M. D., .	December 12, 1838.	55	
90	On the Lead Mines in the County of Clare, .	P. M. Taylor, Esq., . .	. . . .	. .	Journal, vol. i. p. 385.
91	On the Geology of Ayrshire, ...	C. W. Hamilton, Esq., .	January 16, 1839. .	55	

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
92	On the Occurrence of Azote in various Rocks,	Captain Portlock, . .	January 16, 1839. .	55	MS. in Library.
93	On a Bed of Trap in the New Red Sandstone near	James Bryce, Esq., . .	January 16, 1839. .	56	
94	Annual Meeting of	Captain Portlock, . .	February 13, 1839.	57	Journal, vol. ii. p. 1.
95	of the District between the Dublin and Mourne Mountains,	C. W. Hamilton, Esq., .	March 13, 1839. .	57	Journal, vol. ii. p. 51.
96	On the Fossiliferous Strata in the neighbourhood of Youghal,	Robert Ball, Esq., . .	March 13, 1839. .	57	
97	On the Gold Mines in the County of Wicklow,	Aquilla Smith, M. D., .	April 10, 1839. . .	58	
98	On the Contact of Mica Slate and Limestone at the Rosses, near Sligo,	Archdeacon Verschoyle,	May 8, 1839. (?) .	58	Journal, vol. ii. p. 70.
99	On the Geological Relations of the Slates and Limestones of the Counties of Cork and Kerry,	Richard Griffith, Esq., .	June 12, 1839. . .	59	Journal, vol. ii. p. 78. (Journal has "June 13.")
100	On Fossil Entromostraca, ...	John Scouler, M. D., .	June 12, 1839. . .	59	
101	On Bogs, ...	Robert Mallet, Esq., .	June 12, 1839. . .	59	
	Session, 1839–40.				
102	On Coast of Louth and Dub- of Lambay,	C. W. Hamilton, Esq., .	November 18, 1839.	59	MS. in Library.
103	On effected in the Classifica- f the Specimens in the So-	John Scouler, M. D., .	December 11, 1839.	60	
104	On the Metallurgy of Iron, Copper, Lead, and Tin,	Robert Mallet, Esq., .	December 11, 1839.	60	
105	On some new species of Fossils discovered by him in the Collection of the Society,	Frederick M'Coy, Esq.,	January 8, 1840. .	60	Journal, vol. ii. p. 91. (?)

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
106	imestone occurring in the	John Kelly, Esq., . .	January 8, 1840. .	60	
107	Address delivered at Ninth Annual Meeting of Geological Society,	Richard Griffith, Esq., .	February 12, 1840.*	62	Journal, vol. ii. p. 95.
108	On a new Ore of Lead and Antimony, . . .	James Apjohn, M. D., .	March 11, 1840. .	62	
109	On some Fossiliferous Slates in the neighbourhood of Waterford,	Major Austin, . . .	March 11, 1840. .	62	
110	On a new species of Elephant, and some Mollusca,	Frederick M'Coy, Esq.,	March 11, 1840. .	62	
111	On a Substance found in the Substratum of a Peat Bog in the County of Westmeath,	Archdeacon Vignoles, .	April 15, 1840. .	63	If this be the Paper noticed in the Tenth Address (Journal, vol. ii. p. 142), the substance is there stated to have been found in the County of *Kildare*.
112	On the occurrence of Indicolite in the granular white Felspar from the County of Donegal,	Aquilla Smith, M. D., .	April 15, 1840. .	63	
113	On the structure of the Tooth of the Fossil Elephant,	Frederick M'Coy, Esq.,	April 15, 1840. .	63	
114	On some Globular Concretions in Sandstone,	Archdeacon Verschoyle,	May 13, 1840. . .	63	See Journal, vol. ii. p. 184. (Address.)
115	On the Disposition of the Gravel in some Gravel Pits,	C. W. Hamilton, Esq.,	May 13, 1840. . .	63	
116	On Corrections made by him in his Geological Map of Ireland,	Richard Griffith, Esq., .	June 10, 1840. . .	64	
117	On an Analysis of a new Ore of Lead, Sulphur, and Antimony,	James Apjohn, M. D., .	June 10, 1840. . .	64	
118	On the Geology of Connemara, ...	John Scouler, M. D., .	June 10, 1840. . .	65	

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
	Session, 1840–1.				
119	. . . .	Robert Mallet, Esq., .	Nov. 11, 1840. . .	66	Address says "10th June."
120	in the Limestone of the County	James Apjohn, M. D., .	Nov. 11, 1840. . .	66	
121	On the occurrence of Tin-stone at Croghan Kinshela Mountain, in the County of Wicklow,	Aquilla Smith, M. D., .	December 9, 1840. .	66	See Journal, vol. ii. p. 144. (Address.)
122	On the Geology of the Rockabill Islands, . .	C. W. Hamilton, Esq., .	December 9, 1840. .	66	
123	On certain Ochres found in the estate of the Earl O'Neill, in the County of Antrim,	John M'Arthur, Esq., .	January 13, 1841. .	66	
124	Address delivered at Tenth Annual Meeting of Geological Society,	James Apjohn, M. D., .	February 10, 1841.	68	Journal, vol. ii. p. 131.
125	On the recent Formation of some Siliceous Minerals,	Professor Karsten, . .	March 10, 1841. .	68	
126	On some new and rare Fossils found in the Carboniferous Limestone of Clane, in the County of Kildare,	Frederick M'Coy, Esq.,	March 10, 1841. .	68	
127	On M. Agassiz' Work upon the Swiss Glaciers,	Captain Portlock, . .	April 14, 1841. .	69	
128	On the Iron Pyrites or Sulphur Ores of the Ballymurtagh District,	Edward Barnes, Esq., .	May 12, 1841. . .	69	Address has "June."
129	On a method of Analyzing Limestones for the purpose of determining their value for Hydraulic use,	James Apjohn, M. D., .	June 9, 1841. . .	69	
	Session, 1841–2.				
130	On the Changes made in his Geological Map of Ireland, during the years 1839, 1840, and 1841.	Richard Griffith, Esq., .	December 8, 1841.	70	It appears that there was no Paper in November.

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
131	On the Carboniferous Slate of the South of Ireland,	Richard Griffith, Esq., .	December 8, 1841. .	70	
132	On some Fossil Crustacea from the Glasgow Coal District,	John Scouler, M. D., .	December 8, 1841. .	71	
133	On the Changes made in his Geological Map of I . . . . . years 1840 and 1841,	Richard Griffith, Esq., .	January 12, 1842. .	72	
134	On Slate of the South of Ireland,	Richard Griffith, Esq., .	January 12, 1842. .	72	
135	On some Fossil Crustacea from the Glasgow Coal District,	John Scouler, M. D., .	January 12, 1842. .	72	This and the two preceding Papers appear to have been read at last Meeting.
136	Address delivered at Eleventh Annual Meeting of Geological Society,	James Apjohn, M. D., .	February 16, 1842.	72	Journal, vol. ii. p. 178.
137	localities in the F. Jennings, Esq.,	John Scouler, M. D., .	March 9, 1842. . .	73	
138	surface of Rocks ntry Bay,	C. W. Hamilton, Esq., .	March 9, 1842. . .	73	MS. in Library. (Interesting, indeed.)
139	e Presentation of eological Map of Ireland,	C. W. Hamilton, Esq., .	April 13, 1842. . .	73	
140	On	John Scouler, M. D., .	April 13, 1842. . .	73	MS. in Library.
141	On Recent and Fossil,	John Scouler, M. D., .	May 11, 1842. . .	74	
142	On by Mr. Griffith as Chlorite Slate,	C. W. Hamilton, Esq., .	May 11, 1842. . .	74	
143	On Coniferous Plants, both Recent and Fossil,	John Scouler, M. D., .	June 8, 1842. . .	74	
	Session, 1842–3.				
144	On the Proofs of Elevation in the Valley of the Clyde,	John Scouler, M. D., .	November 9, 1842.	76	

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
145	On a Sil[illegible] [illegible] by him north [illegible] Mayo,	Richard Griffith, Esq., .	December 14, 1842.	76	MS. in Library. Paper says "west" of Ballaghderreen.
146	On the Mastodon Giganteum, with Note by Koch,	John Scouler, M. D., .	December 14, 1842.	76	MS. in Library.
147	On Fossils from Baffin's Bay, ...	John Scouler, M. D., .	January 11, 1843. .	77	
148	Address delivered at Twelfth Annual Meeting of Geological Society,	John Scouler, M. D., .	February 8, 1843. .	79	Journal, vol. ii.
149	On Fossil Botany, with remarks on some Fossils lately presented to the Society,	John Scouler, M. D., .	March 8, 1843. . .	79	
150	On some native Sulphur recently found in Granite in the County of Dublin,	Robert Mallet, Esq., .	April 12, 1843. . .	79	
151	On the Ichthyosaurus, ...	John Scouler, M. D., .	May 10, 1843. . .	80	
152	On Leptæna, ...	John Scouler, M. D., .	June 14, 1843. . .	80	
	Session, 1843–4.				
153	Notice of the Contributions to the Museum of the Society during the Recess,	Professor Oldham, . .	November 8, 1843.	81	
154	On a Series of Horns of the Red Deer found in Ballinderry Lake, in the County of Westmeath.	C. W. Hamilton, Esq.,	November 8, 1843.	81	See Journal, vol. iii. p. 15.
155		Professor Oldham, . .	November 8, 1843.	81	
156		G. V. Du Noyer, Esq., .	December 13, 1843.	81	See Journal, vol. iii. pp. 16, 17.
157	Bantry,	George Wilkinson, Esq.,	December 13, 1843.	81	
158	On some Fossil Wood found at a depth of fifty feet in sinking a well at Nenagh, in the County of Tipperary,	George Wilkinson, Esq.,	January 10, 1844.	82	Noticed in Journal, vol. iii. p. 17.

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
159	On the importa … con- nexion with	George Wilkinson, Esq.,	January 10, 1844. .	82	
160	On a Method of … pying the remains	Robert Ball, Esq., . .	January 10, 1844. .	82	
					Curator's Report comes in here, February 12, 1844. MS. in Library.
161	Address delivered at Thirteenth Annual Meeting of Geological Society,	John Scouler, M. D., .	February 14, 1844.	84	Journal, vol. iii. p. 10.
162	On the Iron Ores of Ireland, ...	Sir Robert Kane, M. D.,	March 13, 1844, .	86	Journal, vol. iii. p. 47.
163	On the relation of Molecular Forces to Geology,	Robert Mallet, Esq., .	March 13, 1844, .	86	Journal, vol. iii. p. 28. MS. in Library.
164	On the Identification of the Histella Sulcata, .	C. Fleming, M. D., . .	March 13, 1844. .	86	
165	On the Bones of Oxen found in the Bogs of Ireland,	Robert Ball, Esq., . .	April 10, 1844. .	87	Journal, vol. iii. p. 50.
166	Report on the Fossil Plants in the Museum of the Society,	Professor Oldham, . .	April 10, 1844. .	87	Journal, vol. iii. p. 49.
167	On the Trap Rocks of Limerick, ...	C. W. Hamilton, Esq.,	May 8, 1844. . .	88	Journal, vol. iii. p. 52. Part of MS. in Library.
168	On the Mineralogical Character of Porphyries,	John Scouler, M. D., .	June 12, 1844. . .	89	Journal, vol. iii. p. 58. MS. in Library.
169	On the Rocks at Bray Head, ...	Professor Oldham, . .	June 12, 1844. . .	89	Journal, vol. iii. p. 60.
170	On the more recent Geological Deposits in Ireland,	Professor Oldham, . .	June 12, 1844. . .	89	Journal, vol. iii. p. 61.
	Session, 1844–5.				
171	Notice on the Temperature of Mines in Ireland,	Professor Oldham, . .	November 13, 1844.	89	Journal, vol. iii. p. 72.
172	On some Timber found at a considerable depth below the surface in the County of Tyrone,	William Murray, Esq., .	December 11, 1844.	90	Journal, vol. iii. p. 75.

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
173	On the Effects of … s connected with the increase … as observed in Mines,	Robert Mallet, Esq., .	December 11, 1844.	90	
174	On a Zeolotic Mineral analyzed by him, . .	James Apjohn, M. D., .	December 11, 1844.	90	Journal, vol. iii. p. 76. MS. in Library.
175	… from the Silurian Rocks … sented by him to the So-	Hugh N. Nevins, Esq.,	December 11, 1844.	90	Journal, vol. iii. p. 78. MS. in Library.
176	On the Marbles of Ireland, ...	George Wilkinson, Esq.,	January 8, 1845. .	91	Journal, vol. iii. p. 80.
177	Address delivered at Fourteenth Annual Meeting of Geological Society,	C. W. Hamilton, Esq.,	February 12, 1845.	92	Journal, vol. iii. p. 97.
178	On som… .	James Apjohn, M. D., .	March 12, 1845. .	93	Journal, vol. iii. p. 120.
179	On the … .	Robert Mallet, Esq., .	April 9, 1845. . .	94	Journal, vol. iii. p. 122.
180	On the … .	Robert Mallet, Esq., .	May 13, 1845. . .	95	Journal, vol. iii. p. 125.
181	On the … of Belfast,	James M'Adam, Esq., .	June 11, 1845. . .	95	Journal, vol. iii. p. 132. MS. in Library.
182	On the Gravel and other recent Geological Deposits in Ireland (supplemental to his Paper read June, 1844).	Professor Oldham, . .	June 11, 1845. . .	96	Journal, vol. iii. p. 130.
	Session, 1845–6.				
183	On the Movements of Gravel Beds and of Erratic Boulders,	Robert Mallet, Esq., .	November 12, 1845.	96	
184	On the succession of Rocks in the neighbourhood of Killarney and Hungry Hill,	C. W. Hamilton, Esq.,	December 10, 1845.	97	Journal, vol. iii. p. 134. MS. in Library.
185	On the Vorticose Movement assumed to accompany Earthquakes,	Robert Mallet, Esq., .	December 10, 1845.	97	Journal, vol. iii. p. 138.
186	On the Cause of the Disease in the Potatoes, .	William Andrews, Esq.,	December 10, 1845.	97	Journal, vol. iii. p. 145.

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
187	On the Trap Rocks of Limerick, ...	C. W. Hamilton, Esq., .	January 14, 1846. .	98	Journal, vol. iii. p. 145. (Journal has "January, 1845.")
188	On the Order of Succession of the Strata in the South of Ireland, with particular reference to the Killarney District of the County of Kerry,	Richard Griffith, Esq., .	January 14, 1846. .	98	Journal, vol. iii. p. 150.
189	On the Formation of Lakes on the Flanks of the Commeragh Mountains,	Hugh N. Nevins, Esq.,	January 14, 1846. .	98	Journal, vol. iii. p. 160. MS. in Library. (Interesting.)
190	Address delivered at Fifteenth Annual Meeting of Geological Society,	C. W. Hamilton, Esq.,	February 11, 1846.	99	Journal, vol. iii. p. 168.
191	On Diurnal and Secular Motions of the Earth's Crust, with some Remarks by R. Mallet, Esq.,	Sir W. R. Hamilton, .	March 11, 1846. .	100	Journal, vol. iii. p. 180. MS. in Library.
192	Structure of the West Coast	G. V. Du Noyer, Esq., .	March 11, 1846. .	100	Journal, vol. iii. p. 187.
193	On Griffithides Globiceps (Portlock), and other Carboniferous Fossils,	Professor Oldham, . .	March 11, 1846. .	101	Journal, vol. iii. p. 188.
194	On the Geology of the neighbourhood of Lisbon,	John Scouler, M. D., .	April 8, 1846. . .	101	Journal, vol. iii. p. 195.
195	On the Marl and Gravel Deposits of the County of Wexford,	Captain James, . . .	May 13, 1846. . .	102	Journal, vol. iii. p. 195.
196	On the Formation of the Fissures of Mineral Veins and Dykes,	Robert Mallet, Esq., .	June 10, 1846. . .	103	Journal, vol. iii. p. 197.
197	'Moraines in Glen- r,	Professor Oldham, . .	June 10, 1846. . .	103	Journal, vol. iii. p. 197.
198	On the Facts disclosed by the Tunnelling Operations at Downhill,	James M'Adam, Esq., .	June 10, 1846. . .	103	Journal, vol. iii. p. 199.
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200	On some Shells said to have fallen during a thunder-storm in the County of Carlow, on the grounds of Oak Park, near the Town of Carlow,	Robert Mallet, Esq., .	November 11, 1846.	104	Journal, vol. iii. p. 201. (Mr. Lock's letter in Library.)
201	On the occurrence of a small Boss of Serpentine Rock, near Roundwood, in the County of Wicklow,	Professor Oldham, . .	November 11, 1846.	104	Journal, vol. iii. p. 202.
202	On a remarkable Deposit of Tufa in a Bog near Roscrea, in the County of Tipperary,	Professor Allman, . .	December 9, 1846.	104	Journal, vol. iii. p. 203.
203	On the Geological Structure of Glenmalur, in the County of Wicklow,	Professor Oldham, . .	December 9, 1846.	105	Journal, vol. iii. p. 205.
204	On the Copper Ores of South America containing Precious Metals,	Robert Mallet, Esq., .	January 13, 1847. .	105	Journal, vol. iii. p. 205.
205	On an Analysis of Serpentine from Connemara, obtained by Matthew D'Arcy, Esq.,	Robert Mallet, Esq., .	January 13, 1847. .	105	Journal, vol. iii. p. 207.
206	Address delivered at Sixteenth Annual Meeting of Geological Society.	Robert Mallet, Esq., .	February 10, 1847.	107	Journal, vol. iii. p. 215.
207	On the (. of Carbonate of Mang Clare,	Sir Robert Kane, M. D.,	March 10, 1847. .	108	Journal, vol. iii. p. 237.
208	On the Results of the Fusion of some Igneous ocks from the County of	Professor Oldham, . .	March 10, 1847. .	108	Journal, vol. iii. p. 239.
209	variety of Hyalite from to the University Museum by Professor Radice,	James Apjohn, M. D., .	April 14, 1847. . .	109	Journal, vol. iii. p. 240.
210	On the occurrence of Syenitic Blocks in the neighbourhood of Bandon,	Professor Allman, . .	May 12, 1847. . .	109	Journal, vol. iii. p. 242.

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212	On Pseudomorphous Crystals of Mica, . . .	Professor Oldham, . .	June 9, 1847. . .	110	Journal, vol. iii. p. 242.
213	On certain peculiarities in the Lamination of the Slates in the South of Ireland,	Robert Mallet, Esq., .	June 9, 1847. . .	110	Journal, vol. iii. p. 244.
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214	Cuttings of the , in the portion abate,	G. V. Du Noyer, Esq.,	November 10, 1847.	111	Journal, vol. iii. p. 252.
215	Remains of the Irish Elk, and of the Rein Deer, found by Mr. Moss, in cutting a mill lead near Kiltiernan, County of Dublin,	Professor Oldham, . .	November 10, 1847.	111	Journal, vol. iii. p. 252.
216	On the occurrence of a Substance resembling Bitumen, found in a Bog at Cappa, near Enfield, County of Kildare,	G. V. Du Noyer, Esq.,	November 10, 1847.	111	Journal, vol. iii. p. 253.
217	On the Sections exposed on the Dublin and Drogheda Railway from Donabate to Drogheda,	G. V. Du Noyer, Esq.,	December 8, 1847. .	112	Journal, vol. iii. p. 255. (Journal has "December 13.")
218	On the Section of the Rock at the Chair of Kildare,	Professor Oldham, . .	January 12, 1848. .	114	Journal, vol. iii. p. 260. (Journal has "January 14.")
219	On the Fossils of the Silurian Rocks of the Chair of Kildare, and the indications they afford of the age of the Strata in which they occur,	Professor Forbes, . .	January 12, 1848. .	114	Journal, vol. iii. p. 261.
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223	On the Molecular Changes of Recent Shells, .	Robert Mallet, Esq., .	April 12, 1848. . .	117	Journal, vol. iii. p. 301.
224	On the Drift of the County of Wicklow, . .	Professor Oldham, . .	April 12, 1848. . .	117	Journal, vol. iii. p. 302.
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226	On some so-called Fucoid Fossils, ...	Professor Forbes, . .	November 14, 1848.	117	Journal, vol. iv. p. 20.
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233	On the Changes of the Earth's Figure and Climate, resulting from Forces acting at its Surface,	Henry Hennessy, Esq.,	March 14, 1849. .	122	Journal, vol. iv. p. 139.
234	On certair ' Australia, presented to the I m by Dr. Todd,	James Apjohn, M. D., .	April 11, 1849. .	123	Journal, vol. iv. p. 142.
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236	On the Geology of the County of Carlow, . .	Professor Oldham, . .	May 9, 1849. . .	124	Journal, vol. iv. p. 146.

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249	Supplement to his Paper read May 8, 1850, .	James M'Adam, Esq., .	June 12, 1850. . .	132	Journal, vol. iv. p. 265.

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VOL. VI. 1853–4. PART I.

November 9th, 1853.—"On the Newer Palæozoic Rocks, which border the Menai Straits, in Carnarvonshire;" by the Rev. SAMUEL HAUGHTON, A. M., Professor of Geology in Trinity College, Dublin.

THE newer palæozoic rocks, in Carnarvonshire, occur on the east side of the Menai Straits, where they form a thin patch, extending N. E. for a distance of upwards of $8\frac{1}{4}$ miles; their greatest breadth, measured in the N. W. direction, being less than one mile. They are bounded on the south-east by one of those bands of felspar porphyry which constitute so remarkable a feature in the geology of north-western Wales, and on the north-west by the Menai Straits.

I have selected this district for examination from the fact of its appearing to contain a complete series of deposits, extending from the upper Devonian sandstones and conglomerates on the north, to the shales and marl beds of the coal measures on the south; thus affording, on a small scale, a section of the Welsh deposits which correspond to the Devonian sandstones and carboniferous limestones which occur on so much larger a scale in our own country.

I have endeavoured to ascertain with some degree of accuracy the thickness of the various beds composing this district, and have carefully recorded the position of the numerous fossils with which the limestone beds abound.

The measures obtained for the beds connecting the upper Devonian sandstones with the lower Carboniferous limestones I consider to be satisfactory and accurate; but the relations existing between the limestone and the coal shales resting upon it are more obscure, and with reference to this part of my Paper, I do not feel quite so confident in the accuracy of my measurements.

With the view of elucidating the structure of the newer palæozoic beds to the east of the Menai Straits, I have also examined the western shore of the Straits, where the same or a similar series of beds occurs, and I have found the conclusions drawn from the examination of the eastern shore fully borne out by the observations made by me on the corresponding beds of the western side of the Menai; but as I had not an opportunity of following the latter inland, I have not thought fit to include the palæozoic rocks of Anglesey in my description, but have contented myself with using the latter to corroborate the observations made on the structure of the former.

For the convenience of description I shall divide my subject into the following parts: a sketch of the physical geology of the district; the details of measured thicknesses of beds; the fossils characteristic of each; and a few deductions which appear to be naturally suggested by the observed facts.

PHYSICAL GEOLOGY OF THE DISTRICT.

The eastern, or rather south-eastern, boundary of the district is nearly a straight line of fault, which is traced on the map of the Geological Survey. The total length of this line, which bears E. 47° N., is 8·46 miles, of which about $1\frac{1}{4}$ miles on the north is bounded by metamorphic slate and conglomerate; the remaining $7\frac{1}{4}$ miles being bounded by felspar porphyry containing quartz crystals (Eurite), which terminates abruptly on the south in Twthill, near Carnarvon. This rock is locally called granite, and it is almost deserving of the title, as it is nothing but a granular compound of felspar and quartz in about equal proportions, distinctly crystallized; it preserves its texture pretty uniformly, excepting that it is finer and more compact in the northern portion, and is the most quartzose of all the bands of felspathic rock which intersect Carnarvonshire from N. E. to S. W.

The western boundary of the newer palæozoic district extends

from Russell's oyster beds, near Bangor, on the north, to the town of Carnarvon on the south. The total length of this line is 9·35 miles.

CARNARVON

On the western shore of the Menai, the newer palæozoic rocks extend from a point less than half a mile west of Britannia Bridge to the southern extremity of the Straits. The northern boundary may be fixed on a map by the observation that the house in Vaynol Wood bears from it S. 30° W. (Mag.)

An inspection of the accompanying outline Map will show that on the western boundary the general strike of the beds coincides with the line of coast, with the exception of the part contained between the Menai Bridge and the point marked (*c*). From the Menai Bridge to the point (*b*) there is a slight deviation of the strike from the coast line, so as to expose (neglecting faults) beds successively older; while from the point (*b*) to the point (*c*) the deviation is such as to show beds successively newer: it will be also perceived from the map, that this is owing to the change in direction of the coast line, and not of the line of strike, which is very constant along the whole coast, and in its average direction is nearly W. 26° S., i. e. mag. E. W. In going inland, the line of strike is considerably disturbed, particularly near the eastern boundary and northern extremity of the district, where it is

frequently thrown into a direction at right angles with the average direction.

The explanation of the fact just mentioned is one of the problems of the district, which appears to me to be fully elucidated by the trap dykes and secondary faults, which I shall now proceed to describe.

Trap Dykes.—The district under examination is intersected by three systems of trap dykes, which occur at the following points, and with the following bearings:—

1. At a point half a mile west of Russell's oyster beds, two dykes of highly crystalline trap occur, composed of well-developed crystals of felspar and augite, and weathering into nodular masses of a greenish-brown clay; these dykes are nearly vertical, and intersect the cliff from top to bottom, cutting and altering the blue limestone in a quarry at the top into a crystalline marble, and changing the arenaceous beds at the bottom into a hard siliceous slate. The northern dyke is 14 feet wide; and the breadth of the whole system, measured at the top, is 106 feet.

The northern dyke bears E. 40° S., and if produced would pass under the farm-house in Nant y borth. It will be seen by the Map that the line of its prolongation would cut the eastern boundary at a point where the limestone and conglomerate beds are greatly disturbed.

2. The second dyke occurs at a point a quarter of a mile south of the point opposite Plas Newydd; it is very much decomposed, but appears to be identical in composition with the first dyke, and alters in a similar manner the limestone intersected by it.

It bears E. 35° S.

3. The third series of dykes occurs at the church of Llanvairisgaer, and consists of a number of dykes which intersect and alter, in a remarkable manner, a red, loose conglomerate which occurs at this point, dipping at a small angle inland. The principal of these dykes are laid down on the map.

The dyke south of the church is 8 feet wide.

The most northern dyke is 5 feet wide, and bears S. 45° E.

Between these two dykes occur a number of thin veins of trap, about one foot wide, which intersect the conglomerate in various directions, and change it into a gray, flinty conglomerate.

A minute description of these trap dykes, and of the alterations produced by them in the red conglomerate, was read before this Society, by Mr. Trimmer, in 1838, and is printed in our Journal, vol. ii. p. 35.

The parallelism and similarity of texture of these three systems of trap dykes is remarkable; and it is also to be observed, that their mean direction, E. 40° S., is almost perpendicular to the direction of the porphyritic band which bounds the district on the east.

Faults.—The faults in the northern end of the district are very numerous, although they do not appear to have produced much disturbance in a vertical direction. Those whose bearing I was able to ascertain are here given:—

1. There is a vein of sulphate of barytes, containing a little galena, in the North Swilly rock, in red micaceous slate, from 1 inch to 5 inches wide. This vein bears S. 26° E. (N. S. mag.)

2. In the railway cutting near the Britannia Bridge there are four faults, which bear as follows:—

1. Bears,	. . . .	E. 4° S.
2. „	. . . .	S. 16° E.
3. „	. . . .	S. 4° W.
4. „	. . . .	S. 16° E.

The first and third of these are at right angles, and the second and fourth are parallel.

3. On the Anglesey shore, at one-third of a mile north of Plasnewydd, there is a slight fault, which bears S. 16° E.

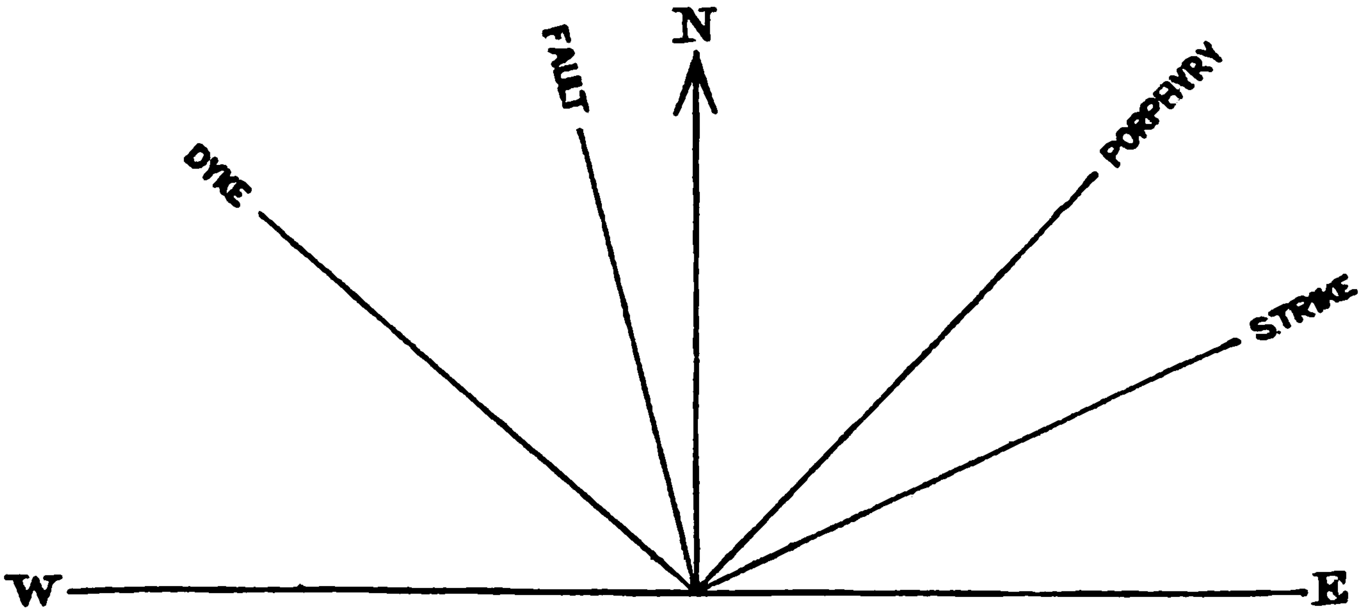
Rejecting the first of the second system, as belonging to the perpendicular group of faults, we find the mean direction of faults to be S. 14° E.

The mean of twenty-four measurements of the strike of the beds of limestone and sandstone through the whole of the undisturbed part of the district gives E. 27° N. mag. E. W. nearly. Consequently, the average direction of the faults makes an angle of 77° with the average direction of the strike.

It has been already shown that the average direction of the trap dykes makes an angle of 87° with the average direction of the porphyritic dyke, which is well represented by the eastern boundary of the palæozoic rocks.

The relations between the lines of strike and fault, and the di-

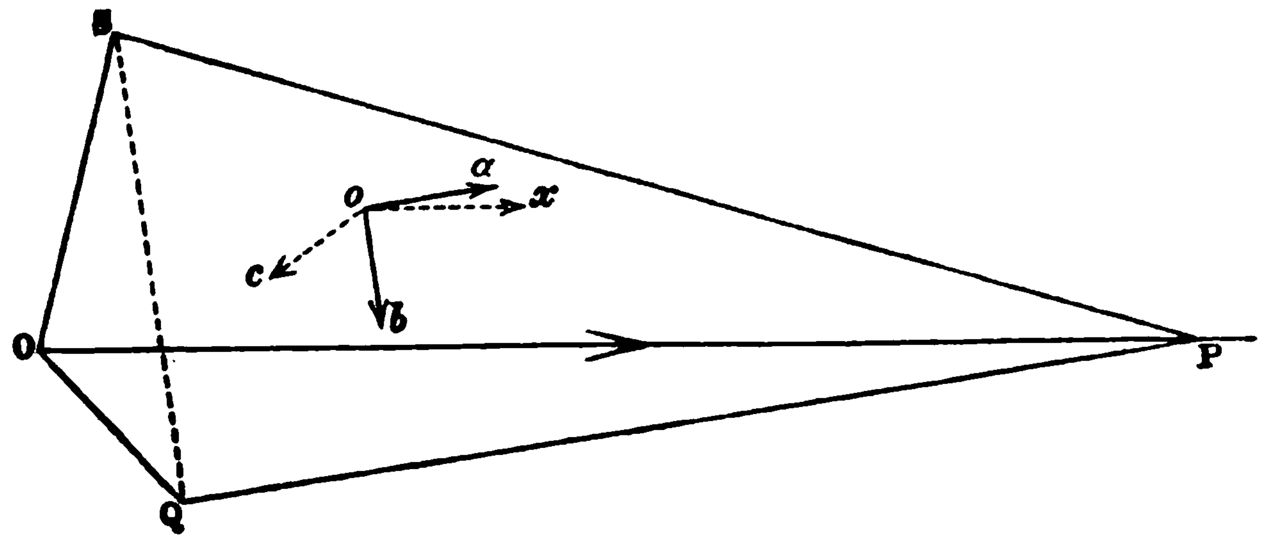
rections of the porphyry and trap dykes, are shown in the accompanying diagram. These relations appear to me to admit of explanation on physical principles, and to throw light on the structure of the entire district.



The band of porphyry is clearly of an age much earlier than the palæozoic rocks under consideration: this is shown by its parallelism to the other porphyritic and syenitic bands of North Wales, and to the line of strike of the Cambrian rocks which border its eastern side. The newer palæozoic beds dip towards the porphyry band, and appear to have been originally deposited quietly upon its western slope. Some cause or combination of causes—either alteration of relative level, or lateral pressure, or a combination of both—gave to these beds a slight dip towards the south-eastern side, and a line of strike making an angle of 20° with the band of porphyry. This line of strike is shown by the figure to lie to the south of the porphyry band. A series of trap dykes, making an angle of very nearly 90° with the porphyry, intersected and thrust upwards the palæozoic beds; and it is to the action of these dykes we must attribute the faults which are found in the latter.

The direction of the porphyry band, and the line of strike of the palæozoic rocks, are to be admitted as ultimate facts. The perpendicularity of the trap dykes to the porphyry is a fact quite in accordance with the known laws of volcanic action; and the fact to be explained is, the direction of the lines of fault consequent on the conditions supposed. If the strike of the beds were parallel to the porphyry dyke, the action of the trap dykes would be to rend the beds in a direction either parallel to the line of dip or of strike. In the case we are considering, the line of strike makes an angle of 20°

with the porphyry; and the effect of the intrusion of trap dykes perpendicular to the latter is to produce a series of faults, not perpendicular to the porphyry, but making with it an angle of 57°,—the perpendicular being, as it were, pushed towards the line of porphyry.



In the annexed figure, let OPS denote a horizontal plane, OP the bearing of the porphyry band, OS the trap dyke at right angles to it, PSQ the plane of a limestone or other bed, the point Q being vertically under the point O; SP is the line of strike, making an angle of 20° with the line OP. The intrusion of the trap dyke in the plane OSQ produces, on the whole, a lateral pressure on the bed SQP, acting in a direction parallel to OP, or perpendicular to the plane of the dyke. This lateral pressure *ox* at any point *o* of the plane SQP may be resolved into three directions at right angles to each other: *oa* parallel to QP; *ob* perpendicular to QP, and lying in the plane of the bed SPQ; and *oc* perpendicular to the plane SPQ. The effect of the forces *ob* and *oc*, which lie in the plane perpendicular to the line QP, will be to turn and bend the plane SPQ round the line QP, and to break it in directions parallel to QP and *ob*, which is perpendicular to QP; but it can be shown by mechanical considerations* that the effect of the forces parallel to *oa* will be to shift the lines of fracture to the right, and give the plane SQP a tendency to break in two directions,—one lying inside the angle SQP, and the other at right angles to it: but the angle SQP is less than 90°, and therefore the angle made by the line of fault will *a fortiori* be less than 90°. The effect of the lateral force *oa* will be different at different parts of the bed or plane SPQ. In the investigation contained in the note I have endeavoured to show,—

* See Note at end of Paper.

1st. That at very great distances from the line QP its effect will not be sensible in distorting the line of fracture, but that it will conspire with the forces *ob* and *oc* to break the bed in a direction at 90° with QP. 2ndly. That at points situated very near the line QP, the effect of the lateral forces *oa* will be to shift the line of fracture to the right through 45°, so that the bed will tend to break along a line making with QP an angle of 45°. And 3rdly. That its effect at intermediate points will be intermediate; or, in other words, that the line of fracture will lie between 45° and 90°; approaching the former as the point considered lies nearer to QP, and approaching the latter as it lies at a greater distance.

The actual directions of the faults observed range from 39° to 69° with the porphyry dyke, and the mean of the whole is 57°. This may be considered as a sufficient confirmation of the theory, when we consider the multitude of disturbing causes unknown to us (such as the peculiarities of direction and pressure of each dyke, and local varieties of composition and strength in the beds fractured), which have been necessarily omitted in the theory, and which undoubtedly exert an influence upon the phenomena observable in the field.

On the whole, I am inclined to consider the features exhibited by the physical structure of the district under consideration to be explicable on known mechanical principles; and though I may have erred in some of the inferences I have drawn, and possibly a simpler and more complete account of the phenomena might be given, yet I have the utmost confidence in the principles on which I have endeavoured to explain the facts, and wish to express my conviction that the attention of geologists must sooner or later be directed to the necessity which exists of removing from physical geology the reproach of vagueness and looseness of expression which has been often made against it, by more exact observation of the facts of physical structure of the beds which are constantly presented to our notice in disturbed districts.

It has been supposed, in the foregoing inferences, that the beds were held fixed by the porphyry dyke, and it is on this supposition that I have drawn the conclusion that near that dyke the angle made by a fault would probably be 45°. If, however, as appears to have actually occurred, the beds should slide or slip along the porphyry dyke, in consequence of the lateral pressure; the second in-

ference drawn above will require to be modified, and the angle made with the porphyry dyke will be less or greater than 45°, according as the compression of the beds parallel to the porphyry dyke is less or greater than the compression perpendicular to that dyke.

MEASUREMENTS OF THICKNESS OF STRATA.

I shall describe the details of the measurements of the strata, commencing from the N.E. point at Russell's oyster beds, and proceeding in a south-westerly direction along the shore of the Strait.

About 200 yards S.W. of Russell's house the *first fault* occurs, the direction of which I was unable to ascertain further than that it slopes towards the porphyry dyke in the same direction as the other beds of the district.

To the eastward of this fault may be observed the following series of beds:—

I.—*Section N.E. of Fault near Russell's House.*

	Feet.
1. Gray shale,	3
2. Brown shale,	2
3. Red and purple slaty marls,	5
4. Brown and yellow sandy shale,	2
(*Top of Cliff.*)*	
5. White sandstone conglomerate, containing angular fragments of red flint,	15
6. Brown shaly limestone,	14
7. Dark and purple marls, with nodular beds in centre,	8
	49

If the beds Sect. I. 6, 7, represent the beds Sect. III. 1, 2, and Sect. IV. 1, 2,—which I consider not improbable (from the fact observed in Nant y Borth, that the conglomerate rests immediately on a blue crystalline and nodular limestone),—then this fault will be accompanied with a down-throw to the N. E. of about four feet.

The bed No. 5 is very characteristic of this section, and may easily be recognised by the occurrence of the peculiar red flinty pebbles. I observed this bed to occur in two places inland, in Nant y Borth, which are marked on the map; and in one of these places the conglomerate is seen to lie over the beds of limestone;

* The horizontal line drawn through this section denotes the same physical level as the corresponding line, Sec. II.

from which circumstance, coupled with the section south of Russell's house, No. II., I infer that at this fault the down-throw is on the N.E.

II.—*Section S. W. of Fault near Russell's House.*

		Feet.
1.	Coarse blue crystalline limestone,	6
2.	Calpy blue limestone and shale,	7
3.	Gray sandy limestone, containing *Producta gigantea*,	8
4.	Dark and purple shale,	6
5.	Nodular limestone, resting on red marl,	7
	———(*Top of Cliff.*)———	
6.	Blue crystalline marble,	1
7.	Brown shaly limestone, containing other beds of blue marble, one foot thick,	26
8.	Yellow, black, and brown calcareous shale,	17
		78

The beds, Sect. I. 4, 5, are identical with Sect. III. 6, 7, 8, and Sect. IV. 5.

At the system of trap dykes north of the George Hotel, which has been already described (p. 4), the *second fault* occurs, accompanied with a down-throw to the N.E. amounting to 19 feet; this may be seen from the following sections, which are taken at opposite sides of the fault:—

III.—*Section N. E. of Trap Dykes near George Hotel.*

		Feet.
1.	Coarsely crystalline compact limestone, containing *Producta gigantea*, var. *Scoticus*,	17
	———(*Top of Cliff.**)———	
2.	Black and yellow marl,	4
3.	Nodular limestone and red marl,	6
4.	Blue crystalline limestone, altered by trap dyke, and containing *Producta gigantea*,	14
5.	Thinner beds of do. do.,	6
6.	Purple marl,	4
7.	Nodular limestone,	8
8.	Purple and greenish marl,	4
		58

* The horizontal line in this section corresponds to the top of the cliff, and denotes the same physical level as the line in Sec. IV.

The beds, 6, 7, and 8, of this section are identical with Sect. II. 4, 5, and Sect. IV. 5.

In the cliff and quarry S. W. of these dykes the following section was obtained:—

IV.—*Section S. W. of Trap Dykes near George Hotel.*

		Feet.
1.	Crystalline and calpy blue limestone,	6
2.	Yellow nodular limestone,	6
3.	Compact crystalline blue limestone,	16
	(*Top of Cliff.*)	
4.	Thinner beds of do. do.,	11
5.	Beds of red marl, with nodular limestone in the centre,	12
6.	Compact and calpy brown limestone, passing into brown calcareous sandstone,	14
		65

The beds Sect. IV. 5 are identical with Sect. III. 6, 7, 8, and Sect. II. 4, 5; from which may be inferred that the alteration in level produced by these dykes is 19 feet, the down-throw being towards the N. E.

Proceeding along the Strait in a S. W. direction, we find the *third fault* about a quarter of a mile N. E. of the George Hotel. This fault is accompanied by a down-throw to the N. E., the amount of which I was unable to ascertain. In consequence of this fault, the beds of sandstone which underlie the limestone of the district appear in the cliffs, and occupy the place of the limestone, with scarcely any exceptions, for a distance of 2·19 miles, to the point in Vaynol Wood, where the limestone reappears, and afterwards continues for 3·88 miles, without interruption, to the church of Llanvair Isgaer, where, in its turn, the limestone is succeeded by the clay and marl beds of the upper Carboniferous formation.

The subjoined section shows the succession of beds exhibited in the cliffs between the George Hotel and the fault just mentioned.

V.—*Section N. E. of George Hotel.*

		Feet.
1.	Brown shaly limestone, in beds about one foot in thickness, alternating with shaly beds,	15
2.	Yellow sandstone and dark-coloured shales, alternating in one foot beds,	10
3.	Dark-coloured arenaceous shales,	14
4.	Soft uniform yellow sandstone, with numerous impressions of plants,	6
		45

The bed Sect. v. 4 is the same as Sect. VII. 3; and Sect. v. 1 is probably the same as Sect. VI. 3.

The *fourth fault* which I shall describe occurs at about 200 yards N. E. of the Menai Bridge.

The following sections were made at each side of it; from which, and the Table given p. 16, we may infer a down-throw to the N. E. of about 29 feet:—

VI.—*Section N. E. Side of Fault at Menai Bridge.*

	Feet.
1. Compact blue limestone,	6
2. Black and red marl,	5
3. Yellow calcareous sandstone,	1
4. Purple marl,	5
5. Brown arenaceous crystalline limestone, with occasional beds of nodular limestone and shale,	16
(*High Water Mark.*)	
	33

The horizontal line at the bottom of this section is on the same physical level as the corresponding line in Sect. VII.; and probably the bed Sect. VI. 3 is the same as Sect. v. 1, and Sect. VII. 3 the same as Sect. v. 4.

VII.—*Section S. W. Side of Fault near Menai Bridge.*

	Feet.
1. Yellow sandstone and black shale, alternating in beds about one foot thick,	12
2. Black shale	6
(*High Water Mark.*)	
3. Soft yellow sandstone and conglomerate, with numerous impressions of plants,	7
4. Dark-coloured shale and yellow sandstone, alternating; the sandstone beds being about one foot thick,	13
5. Yellow and white sandstone and conglomerate, with impressions of plants,	15
6. Purple marl,	Unknown.
	53

The bed No. 5 forms the foundation on which the pier of the first arch, east side of the Menai Bridge, is built.

At the back of the George Hotel, in the railway cutting, 9 feet above the roadway of the bridge, a compact blue limestone occurs, containing *Producta gigantea* and *Lithodendron sexdecimale;* its strike coincides with that of the beds composing Section VI., and its dip

is 40°. It is at a height of 103 feet above the bottom of Section VI.; and as the dip of the beds in Section VI. is much below 40°, if we assume 30° as the average dip, it is easy to calculate that we should add at least 56 feet of limestone beds to the top of Section VI.

Westward of the Menai Bridge the *fifth fault* occurs, near the house at the foot of cliff; it is very obscure, but probably accompanied with a down-throw to the N. E.

The following section was obtained with some difficulty at the waterfall to the west of this house:—

VIII.—*Section near Waterfall W. of Menai Bridge.*

	Feet.
1. Flaggy white sandstone,	10
2. Purple marl,	5
3. White sandstone and conglomerate, alternating with red shaly beds,	12
4. Soft purple slaty marl, containing pisolitic concretions of brown peroxide of iron,	19
5. Hard red sandstone and purple slate,	2
6. Soft purple slate,	4
7. Red sandstone conglomerate, containing reddish-coloured mica slate and quartz pebbles,	1
8. Purple slate,	10
	63

The beds Sect. VIII. 1 probably represent Sect. VII. 5.

The pisolitic brown hæmatite concretions, mentioned in No. 4, occasionally pass into a hard pisolitic red hæmatite ore, which at one point attains a thickness of more than two feet. The point where the ore appears to be most abundant may be found by the following observation: the bearing of the Marquis of Anglesey's pillar from it is N. W. (mag.).

The following analyses show the average composition of both kinds of ore:—

Analysis of Brown Pisolitic Hæmatite, Menai Straits.

	Per Centage.
1. Loss by ignition, being water, carbonic acid, &c.	10·36
2. Clay and silica,	37·16
3. Peroxide of iron,	49·36
4. Alumina,	Trace.
5. Lime,	1.76
6. Magnesia,	0·32
7. Loss in analysis,	1·04
	100·00

The above analysis shows that the per centage of metallic iron in the raw ore is 34·55, and that it would be in the roasted ore 38.54. If this were used as an ore of iron it would require a large amount of lime to be added, in consequence of the high per centage of silica.

Analysis of Red Pisolitic Hæmatite, Menai Straits.

	Per Centage.
1. Loss by ignition, being carbonic acid, &c.,	4·88
2. Clay and silica,	30·68
3. Peroxide of iron,	62·59
4. Alumina,	1·07
5. Lime,	0·67
6. Magnesia,	Trace.
Loss in analysis,	0·11
	100·00

This analysis shows for metallic iron a per centage of 43·81, which is somewhat greater than that of the brown clayey ore; but both of these ores would require a large addition of bases, in order to flux with advantage.

Near the Britannia Bridge the beds are dislocated by the *sixth* series of faults, which have been described (p. 5), as they occur in the railway cutting behind the bridge.

To the south of the bridge the following series of beds may be traced:—

IX.—*Section S. W. of Britannia Bridge.*

	Feet.
1. Nodular blue crystalline limestone, containing *Cyathophyllum fungites*, the highest bed visible in the quarry being about the level of the bottom of the tube,	7
2. Not seen,	69
3. Brown sandstone conglomerate, and yellow sandstone, with impressions of plants, in flaggy beds,	9
4. Compact massive brown sandstone conglomerate, and white sandstone, with impressions of plants,	16
5. Dark-coloured and purple slaty shales and marls, with some thin hard beds,	11
6. Coarse brown and white conglomerate, with impressions of plants, and thin dark-coloured shale partings, containing nodules of iron pyrites,	20
	132

The eastern pier of the bridge, next the water, rests on the conglomerate bed marked No. 6; and the bed Sect. IX. 3 is probably equivalent to Sect. VIII. 1 and Sect. VII. 5.

In the railway cutting behind the Menai Bridge occurs a series of beds, with a strike 16° W. of N., and dip 8° E. This direction of strike is within about 10° of being at right angles with the average strike of the district, and is parallel to the strike of the highly disturbed beds already described in Nant y Borth.

The following section was obtained in this railway cutting:—

X.—*Section, Railway Cutting behind Menai Bridge.*

		Feet.
1.	Loose red sandy limestone, decomposing into a gravel,	21
2.	Brown and pink arenaceous limestone, somewhat more compact,	26
3.	Pink and reddish sandstone and conglomerate,	7
4.	Red shale,	1
5.	Grayish yellow arenaceous limestone,	1
6.	Black and yellow shale,	8
7.	Coarse pink and gray limestone, turning into sandstone conglomerate in lower beds,	16
8.	Dark-coloured shale,	8
9.	Coal, and impressions of plants,	0·4
10.	Brown, pink, and red gritty limestones, with frequent beds of coarse siliceous conglomerate; or rather the limestone itself passes into and frequently becomes conglomerate,	37
		115·4

This section is remarkable for the occurrence of the conglomerate beds in the midst of pure limestone; and it should be observed that the same circumstance is observable in the disturbed beds of Nant y Borth, although the conglomerate of Nant y Borth is peculiar, and cannot be confounded with the pink-coloured conglomerates of this section: these latter resemble the conglomerates found in the limestones near Porth Dinorwig, which belong to some of the most recent beds of the district. The occurrence of four inches of coal, which can be burned, has led to erroneous speculation as to the probability of coal being found in the neighbourhood, and trials have been actually made near the Britannia Bridge, at the base of the limestone, in the upper Devonian beds, in consequence of the occurrence of large crushed stems of plants, resembling those found in the true coal measures.

The following section was obtained in the cutting immediately

behind the Britannia Bridge, and the beds measured in it overlie the top of the Section IX.:—

XI.—*Section, Railway Cutting near Britannia Bridge.*

	Feet.
1. Purple shale and nodular limestone,	5
2. Close-grained, fine, compact blue limestone,	5
3. Dark-coloured shale,	3
4. Bluish-gray limestone, massive,	8
5. Blue limestone and dark-coloured shale in thin beds, containing *Producta gigantea*,	4
6. Dark and purple marl,	3
7. Purple and greenish conglomerate and compact sandstone,	8
	36

The beds Sect. XI. 1, 2, are probably equivalent to Sect. IX. 1.

The series of sandstone conglomerates and shales described at the base of Section IX. continue in a S. W. direction as far as the wall marking the N. E. boundary of Vaynol Wood. About 150 yards beyond this wall, red and purple marls, interstratified with compact blue and nodular limestone, appear, and constitute near the centre of Vaynol Wood a low anticlinal undulation: these beds are very fossiliferous, and distinguishable from all other beds in the district. Beyond Vaynol Wood the bedding is concealed by shingle as far as the point opposite Plasnewydd; from which point to Porth Dinorwig it is clearly exhibited in the cliffs, and appears to have undergone no disturbance, with the exception of that caused by the trap dyke (p. 4), already mentioned.

As the beds hitherto described are those in which the Devonian rocks appear, and as these rocks are not found further south, it will be useful to attempt from the sections already given to ascertain the total thickness of the lower beds in the northern part of this district.

The following general section, constructed on the scale of $\frac{1}{144}$th, exhibits the final result of all my measurements. Each section is numbered in it, and placed in its correct geological position; and the only section respecting whose place I have had any doubt is Section I.; but this I have placed, for the reason stated (p. 9), in the position it occupies in the general section; it appears to fit in accurately enough with Sections III., IV., and VI.:—

VERTICAL SECTIONS OF LOWER CARBONIFEROUS BEDS OF MENAI STRAITS.

slaty shale.

Coarse sandstone conglomerate, with thin beds of shale and nodules of iron pyrites.

Soft, purple, slaty marls; pisolitic iron clay.

Pisolitic red hæmatite; purple slate, with thin beds of red conglomerate.

Brown shaly

Calpy brown limestone, and brown calcareous

Brown and gray crystalline, arenaceous, and

Brown calpy limestone, and

The total thickness of the beds contained in the foregoing Table is 204 feet, which may be deduced from the vertical columns; while horizontal lines drawn through the columns show the manner in which strata of the same geological age, but differing somewhat in lithological character, were deposited in different parts of the same basin.

The beds already described lie between the points marked *a* and *b* on the map (p. 3); and the lowermost of these beds, near the point *b*, are the oldest beds exposed in the district. From the point *b* to the trap dyke opposite Plasnewydd the beds are imperfectly visible, but are well seen from the trap dyke to the point near Porth Dinorwig, marked *c* on the map. Between these two points they are not broken by any fault, and dip steadily in the same direction, and with nearly the same angle of about 10° from the point *b* to *e*; from *e* to *c* the strike continues the same, but the dip is greater—from 20° to 25°.

From *b* to *e* the beds are composed of calpy yellowish and brown limestone and shaly deposits, which are very fossiliferous; one bed in particular, near the point *e*, north of Bryn Adda lime quarry, being formed almost altogether of the *Producta gigantea*, with a few varieties of *Astræa*, *Calamopora*, and *Lithodendron*. The direction of the coast line between the trap dyke and Bryn Adda makes with the strike an angle of 60°, the distance being 2596 feet. From these data, and the assumption that the dip is 10°, we can calculate the thickness of the beds to be $2596 \times \sin 60° \times \sin 10° = 390$ feet.

From the point *e* to *c* the lithological character of the beds is as follows:—In Bryn Adda quarry they are composed of pink and gray close-grained crystalline marble, containing *Lithodendra:* these marble beds are similar to those worked in Anglesey at the opposite side, near Llanedwen. Under these marble beds lie beds of red and pink nodular limestone, which form the upper part of the series from *b* to *e*. Between Bryn Adda and Porth Dinorwig occur two beds of pink coarse sandstone conglomerate; and near the Porth the limestone contains beds of pink chert. At the south side of the basin, near the railway station, the limestone becomes pink, gritty, and crystalline, occasionally conglomeritic and flinty. On the whole, these beds resemble strongly the beds in Section x., which lie over the beds described in the general section facing p. 16.

The average dip of all these beds is certainly over 20°, but I shall

take them at 20°, so as to obtain a *minimum* thickness; and as the distance from the point *e* to the south side of the basin at Porth Dinorwig is 1540 feet, measured perpendicularly to the strike, the thickness of the beds will be $1540 \times \sin 20° = 526$ feet.

To the S. W. of Porth Dinorwig, at Dinas Head, the beds are greatly contorted, the strike remaining the same; and between these two points a remarkable red clayey conglomerate makes its appearance which constitutes the uppermost bed in the limestone series of the district. To the west of Dinas Head this conglomerate again shows itself, forming a steep cliff, which lies upon a series of red limestone and sandstone conglomerate rocks, which increase in dip (inland) from 30° to nearly 90°, which latter occurs near the centre of Llanvair Wood.

To the S. W. of Llanvair Wood the red clayey conglomerate again appears, forming a low cliff, which might easily be mistaken for a bed of drift; from this point it continues to the church of Llanvair-isgaer, where it is intersected and altered by the intrusion of trap dykes, in the manner already described. The limestone rocks which underlie this conglomerate in Llanvair Wood are coarse, arenaceous, and brown in colour, interstratified repeatedly with a fine red sandstone conglomerate.

I have been led by various considerations to estimate the thickness of the red clayey conglomerate, and the limestone and sandstone beds associated with it, at 450 feet.

To the S. W. of Llanvair-isgaer a series of red clay and fine shaly beds, with occasionally a thin seam of sandstone, rests conformably on the beds already described: these beds are considered to represent the coal measures. I was unable to procure any fossils from these beds, either in Carnarvonshire or Anglesey; and failed, also, in measuring their thickness, as they are overlaid on both sides of the Straits by thick beds of drift, and the line of strike is parallel to the coast line.

It is easy, however, from the position of the porphyry dyke, to assign a major limit to their thickness. The distance from the brick-yard S. of Llanvair-isgaer to the porphyry dyke, measured at right angles to the strike, is 1832 feet; which, multiplied by sin 5° (the dip of red shale beds), gives for the thickness 160 feet.

Adding together the thicknesses measured in the entire district, we find the following total thickness of deposits:—

	Feet.
1. Red shales and marl beds of the coal measures, ...	160
2. Red clayey conglomerate, and associated coarse limestones and sandstones, ...	450
3. Crystalline pink limestone and marble beds, with pink chert and conglomerate, ...	526
4. Nodular red and calpy brown limestones, highly fossiliferous, . .	390
5. Crystalline blue limestone, with beds of red marl and nodular lime stone, resting upon beds of yellow sandstone, conglomerate, and purple slate, ...	204
	1730

Palæontological Observations.

The principal localities in this district in which fossils are abundant are, Vaynol Wood and Bryn Adda, in Carnarvonshire, and Llanedwen quarry, in Anglesey.

The following list contains an account of all the fossils found by me during a search that was far from being complete, and I have little doubt but that it could be easily enlarged by further investigation. As one of my chief objects in examining this district was its comparison with our Irish carboniferous series, I have added a list of Irish localities and formations, divided according to Dr. Griffith's system. For these I am principally indebted to Mr. Richard Byron, who has carefully collated for the purpose Dr. Griffith's valuable collection of Irish fossils:—

Dr. Griffith's divisions of the carboniferous system, in an ascending order, are:—

1. Yellow sandstone group.*
2. Lower limestone.
3. Calp, or middle limestone.
4. Upper limestone.

In the following Table these divisions are represented by the contractions—Y. S, L. L., M. L., U. L.:—

* The following subdivisions of the yellow sandstone group are recognised by Dr. Griffith, in descending order:—

a. Arenaceous limestone; type, north coast of county of Mayo.
b. Arenaceous shale.
c. Carboniferous slate; type, south of county of Cork.
d. Yellow sandstone proper.

Name.	Locality.	Irish Locality.	Irish Formation.
ZOOPHYTA.			
1. **Astræa pentagona,** *Blainv.*	Porthdinorwig.	Largamore, Bangor, Mayo.	Y. S.
2. **Astræa basaltiformis,** *Conyb. & Phil.*	Vaynol Wood.	Tullyard, Armagh.	Y. S.
		Rathcline, Lanesborough, Longford.	L. L.
		Galway and Queen's Counties.	L. L.
		Cookstown, Tyrone.	L. L.
		Bannaghaghole, Leighlin, Carlow.	U. L.
		Raheendoran, Carlow.	U. L.
3. **Lithodendron junceum,** *Keferstein.*	Vaynol Wood.	Hook Point, Fethard, Wexford.	Y. S.
syn. L. sexdecimale, *Phil.*	Moel y Don.	St. John's Point, Dunkineely, Donegal.	Y. S.
L. coarctatum, *Portl.*		Poulscadden, Howth, Dublin.	Y. S.
		Cookstown, Tyrone.	L. L.
4. **Lithodendron cæspitosum,** *Mart. sp.*	Moel y Don.	Soraghy, Castlederg, Tyrone.	Y. S.
		County Leitrim.	L. L.
		Raheendoran, Carlow.	U. L.
		Cookstown, Tyrone.	L. L.
		Lough Gill, Sligo.	L. L.
5. **Lithodendron irregulare,** *Phil.*	Bryn Adda.	Magheramore, Tobercurry, Sligo.	L. L.
syn. L. pauciradiale, *M'Coy.*		Lough Gill, Sligo.	L. L.
6. **Cyathophyllum fungites,** *Goldf.*	Ty Glo.	Kilbride, Ballycastle, Mayo.	Y. S.
syn. Turbinolia fungites, *Flem.*	Britannia Bridge.	Hook Point, Fethard, Wexford.	Y. S.
	Vaynol Wood.	Bruckless, Dunkineely, Donegal.	Y. S.
	Menai Bridge.	Slieve Guillon, Magherafelt, Derry.	Y. S.
		Lisnapaste, Ballintra, Donegal.	Y. S.
		Poulscadden, Howth, Dublin.	Y. S.
		Ballibodonnel, Dunkineely, Donegal.	Y. S.
		Malahide, Dublin.	Y. S.
		Termon, Boyle, Roscommon.	L. L.
		Killala, Mayo.	L. L.
		Lough Erne, Fermanagh.	L. L.
		Ardagh, Drumcondra, Meath.	L. L.
		Little Island, Cork.	L. L.
		Lough Gill, Sligo.	L. L.
		Cleene, Roscommon.	L. L.
		Tralee, Kerry.	L. L.
		Swanlinbar, Ballyconnel, Cavan.	M. L.
		Belmore Mountain, Enniskillen.	U. L.
7. **Cyathophyllum turbinatum,** *Goldf.*	Vaynol Wood.		
8. **Cyathophyllum vermiculare,** *Goldf.*	Vaynol Wood.		
9. **Syringopora ramulosa,** *Goldf.*	Llanedwen.	Bruckless, Dunkineely, Donegal.	Y. S.
		Kilmore, Armagh.	Y. S.
		Malahide, Dublin.	L. L.
		Killymeal, Dungannon, Tyrone.	U. L.
		County Leitrim.	L. L.
10. **Syringopora geniculata,** *Phil.*	Vaynol Wood.	Drumscraw, Drumquin, Tyrone.	Y. S.
		Tinnycahill, Donegal.	Y. S.
		St. John's Point, Donegal.	Y. S.
		Malahide, Dublin.	Y. S.
		Armagh and Malahide.	L. L.
		Clane, Kildare.	L. L.
11. **Syringopora catenata,** *Mart. sp.*	Ty Glo.	St. John's Point, Donegal.	Y. S.
		Unknown locality.	L. L.
12. **Calamopora gothlandica,**	Vaynol Wood.	St. John's Point, Donegal.	Y. S.
syn. Favosites gothlandica, *M'Coy & Portl.*			
13. **Calamopora fibrosa,** *Goldf.*	Vaynol Wood.	Clonea, Dungarvan, Waterford.	Y. S.
	Bryn Adda.	Curragh, Ardmore, Waterford.	Y. S.

Name.	Locality.	Irish Locality.	Irish Formation.
Mollusca.			
14. **Orthoceras unguis,** *Phil.*	Llanedwen.	Clane, Kildare. Little Island, Cork. St. Doolagh's, Dublin. Black Lion, Enniskillen.	L. L. L. L. L. L. U. L.
15. **Bellerophon tangentialis,** *Phil.*	North Menai.	Horath, Moynalty, Meath. Drummanmore, Armagh. Lackagh, Drumquin, Tyrone. Drumscraw, Drumquin, Tyrone. Tirlechen, Ballymahon, Longford. Carlingford, Louth. Ardagh, Drumcondra, Meath. Clane, Kildare.	Y. S. Y. S. Y. S. Y. S. L. L. L. L. L. L. L. L.
16. **Bellerophon apertus,** *Sow.*	Bryn Adda. Llanedwen.	Ardagh, Drumcondra, Meath. Ballyduff, Dungarvan, Waterford. Annaghaigh, Armagh. Tankardstown, Kildorrery, Cork. Carlingford, Louth. Clane, Kildare. Roebuck, Dublin.	L. L. L. L. L. L. L. L. L. L. L. L. L. L.
17. **Euomphalus pentangulatus,** *Sow.*	Vaynol Wood. Bryn Adda.	Ring, Enniskillen, Fermanagh. Bruckless and Rahan's Bay, Donegal. Millicent, Clane, Kildare. Tirlechen, Ballymahon, Longford. Kilmalloch, Limerick. Little Island, Cork. Carrigahorrig, Portumna, Galway. Ballikea, Skerries, Dublin. Tankardstown, Kildorrery, Cork. Ardclough, Rathcoole, Dublin Bundoran, Leitrim.	Y. S. Y. S. L. L. L. L. L. L. L. L. L. L. L. L. L. L. L. L. M. L.
18. **Naticopsis.** *sp.*	Llanedwen.		
19. **Sanguinolaria curta,** *M'Coy, sp.*	Vaynol Wood.	Manor Hamilton, Leitrim.	M. L.
20. **Producta gigantea,** *Sow.*	Llanedwen. Ty Glo. Bryn Adda. Vaynol Wood.	Castle Espie, Comber, Down. Kiltullagh, Roscommon. Killymeal, Dungannon, Tyrone.	Y. S. L. L. U. L.
21. **Producta gigantea,** *Sow.* *var.* **Edelburgensis,** *Phil.*	North Menai.	Ardagh, Drumcondra, Meath. Cregg, Nobber, Meath. Ballyhea, Skerries, Dublin. Ballycastle, Antrim.	L. L. L. L. L. L. U. L.
22. **Producta gigantea,** *Sow.* *var.* **Scotica,** *Sow.*	Penmon.	Drumkeeran, Ederny, Fermanagh. Scraghy, Castlederg, Tyrone. Dromore, Omagh, Tyrone. Castle Espie, Comber, Down. Mullaghgliss, Monaghan. Little Island, Cork. Armagh, Armagh. Cookstown, Tyrone. Dundonagh, Monaghan. Ballintrillech, Bundoran, Donegal. Ballycastle, Antrim.	Y. S. Y. S. Y. S. Y. S. L. L. L. L. L. L. L. L. L. L. M. L. U. L.
23. **Producta hemispherica,** *Sow.*	North Menai. Penmon.	Kilmore, Armagh. Rush, Dublin. Lachagh, Drumquin, Tyrone. Lisnapaste, Ballintra, Donegal. Killelagh, Derry. Dundonagh. Little Island, Cork. Drumcondra, Meath. Ballintrillick, Bundoran, Donegal.	Y. S. Y. S. Y. S. Y. S. L. L. L. L. L. L. L. L. M. L.

Name.	Locality.	Irish Locality.	Irish Formation.
Mollusca—(*continued*).			
24. **Producta quincuncialis**, *Phil.*	Vaynol Wood.	Granard, Longford.	Y. S.
		Townparks, Killeshandra, Cavan.	Y. S.
		Hook, Fethard, Wexford.	Y. S.
		Malahide, Dublin.	Y. S.
		Little Island, Cork.	L. L.
		Rathcline, Longford.	L. L.
		Carnacarrow, Enniskillen.	L. L.
		Brownstown, Meath.	L. L.
		Tullyoran, Mohill, Leitrim.	L. L.
		Bundoran, Donegal.	M. L.
		Old Leighlin, Carlow.	U. L.
25. **Producta antiquata**, *Sow.*	Vaynol Wood. Ty Glo.	Lisnapaste, Ballintra, Donegal.	Y. S.
		Hook, Fethard, Wexford.	L. L.
		Ardclogh, Rathcoole, Dublin.	L. L.
		Millicent, Clane, Kildare.	L. L.
		St. Doolagh's, Dublin.	L. L.
		Carnacarrow, Enniskillen.	L. L.
		Manor Hamilton, Leitrim.	M. L.
26. **Orthis filiaria**, *Phil.*	Bryn Adda.	Bruckless, Dunkineely, Donegal.	Y. S.
		Howth, Dublin.	Y. S.
		Clonea, Dungarvan, Waterford.	Y. S.
		Malahide, Dublin.	Y. S.
		Boyle, Roscommon.	L. L.
		Howth, Dublin.	L. L.
		Finner, Bundoran, Donegal.	M. L.
		Abbey Bay, Ballyshannon, Donegal.	M. L.
		Old Leighlin, Carlow.	U. L.
		Bannaghaghole, Leighlin, Carlow.	U. L.
27. **Orthis crenistria**, *Phil.*	North Menai.	Rahan's Bay, Dunkineely, Donegal.	Y. S.
		Cregganore, Gort, Sligo.	Y. S.
		Ardloughill, Ballyshannon, Donegal.	Y. S.
		Castle Island, Kerry.	Y. S.
		Edenassop, Tyrone.	Y. S.
		Hook Point, Wexford.	Y. S.
		St. John's Point, Donegal.	Y. S.
		Malahide and Howth, Dublin.	Y. S.
		Ardagh, Drumcondra, Dublin.	L. L.
		Brownstown, Meath.	L. L.
		Longford, Longford.	L. L.
		Carrigaline, Cork.	L. L.
		Tankardstown, Kildorrery, Cork.	L. L.
		Millicent, Clane, Kildare.	L. L.
		Bundoran, Leitrim.	M. L.
		Ballintrillick, Bundoran, Leitrim.	M. L.
		Black Lion, Enniskillen.	U. L.
28. **Atrypa fallax**, *Sow.*	Vaynol Wood. Dinas.	Ardoe, Ardmore, Waterford.	Y. S.
		Bruckless, Dunkineely, Donegal.	Y. S.
		Hook Point, Fethard, Wexford.	Y. S.
		Kilnamack, Clonmel.	Y. S.
		Currens, Castle Island, Kerry.	Y. S.
		Cregganore, Gort, Sligo.	Y. S.
		Howth, Dublin.	Y. S.
		Fivemiletown, Tyrone.	Y. S.
		Ballintrillick, Bundoran, Leitrim.	M. L.
29. **Martinia plebeia**, *Sow.*	Vaynol Wood.	Hook, Fethard, Wexford.	Y. S.
		Tullyard, Armagh.	Y. S.
		Lisnapaste, Ballintra, Donegal.	Y. S.
		Millicent, Clane, Kildare.	L. L.
		Ardagh, Drumcondra, Dublin.	L. L.
		Little Island, Cork.	L. L.
		Mullaghfin, Duleek, Meath.	L. L.
		St. Doolagh's, Dublin.	L. L.
		Cookstown, Tyrone.	L. L.
		Brownstown, Meath.	L. L.
		Armagh, Armagh.	L. L.
		Ballintrillick, Bundoran, Leitrim.	M. L.

Name.	Locality.	Irish Locality.	Irish Formation.
Mollusca—(*continued*).			
Martinia plebeia—(*continued*).		Finner, Bundoran, Donegal.	M. L.
		Black Lion, Enniskillen.	U. L.
30. **Reticularia lineata.** *Mart. sp.*	North Menai.	Doorin, Donegal.	Y. S.
		Rush, Dublin.	Y. S.
		Curkeen, Rush, Dublin.	L. L.
		Little Island, Cork.	L. L.
		Tankardstown, Kildorrery, Cork.	L. L.
		St. Doolagh's, Dublin.	L. L.

Of the thirty fossils in the foregoing list, it will be observed that there occur in Ireland in the yellow sandstone group only, three fossils, viz.:—

Astræa pentagona,
Calamopora Gothlandica,
Calamopora fibrosa, . . . 3

In the lower limestone only, two fossils, viz.:—

Lithodendron irregulare,
Bellerophon apertus, . . . 2

In the calp only, one fossil, viz.:—

Sanguinolaria curta, . . . 1

In the yellow sandstone and lower limestone five fossils, viz.:—

Lithodendron junceum,
Syringopora geniculata,
Syringopora catenata,
Bellerophon tangentialis,
Reticularia lineata, ... 5

Four fossils range from the yellow sandstone to middle limestone, viz.:—

Euomphalus pentangulatus,
Producta hemispherica,
Producta antiquata,
Atrypa fallax, ... 4

Two range from lower to upper limestone, viz.:—

Orthoceras unguis,
Producta Edelburgensis, . 2

Two do not occur in Ireland, viz.:—

Cyathophyllum turbinatum,
Cyathophyllum vermiculare, 2

Carried forward, ... 19

	Brought forward, ...	19
One is of undetermined species:—	Naticopsis, *sp.*	1

And ten range through the whole carboniferous epoch in Ireland, viz.:—

Astræa basaltiformis,	
Lithodendron cæspitosum,	
Cyathophyllum fungites,	
Syringopora ramulosa,	
Producta gigantea,	
Producta Scotica,	
Producta quincuncialis,	
Orthis filiaria,	
Orthis crenistria,	
Martinia plebeia, ...	10
	30

In the former part of this paper I have shown that the total thickness of the carboniferous beds in this district, excluding the supposed coal measures, is upwards of 1500 feet, of which the lowest and highest beds contain a quantity of sandstones, cherty, and conglomeritic deposits, indicative of shallow water; and there is reason to believe, that during the time of deposition of the entire group, land was not far distant, as is shown by the abundant remains of crushed stems and vegetable impressions found in the lower sandstones, and in the remarkable seam of coal found in the limestone (p. 15). This seam of coal appears to have been formed from drift-wood, as there is no sign of any "underclay," or other appearance usually supposed to indicate that the plants of which the coal is composed grew on the spot: they appear to have been drifted from the neighbouring land, and when sunk in the sea to have been rapidly covered up by the deposits of chemical and mechanical origin which succeed each other so often in this district. The circumstances under which the beds of this district were deposited were local, and have given rise to a peculiarity in the succession of strata, which renders it impossible to compare them individually with the typical beds of our Irish limestone.

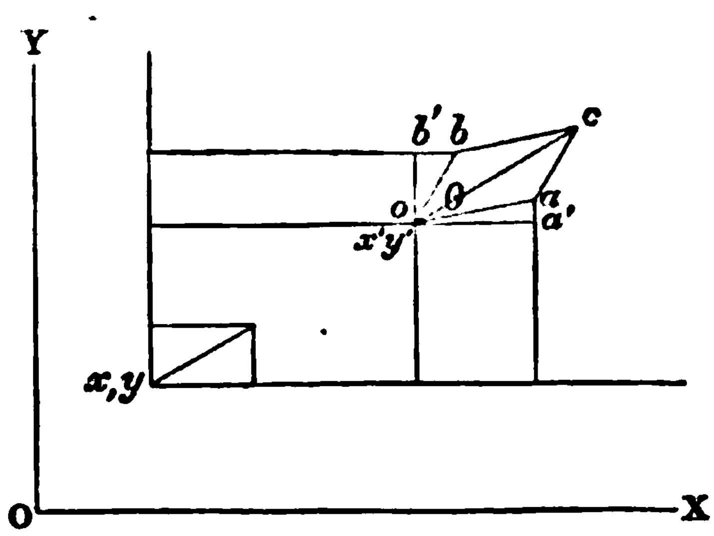
From a careful consideration of the fossils, and a comparison of them with Irish fossils of the yellow sandstone and carboniferous limestone series, I think, that although some of them are what some geologists would call Devonian, yet that there is, on the whole, no

sufficient reason for not considering them throughout as identical with carboniferous fossils. A comparison of these fossils with Gerolstein fossils, from the Eifel, in the Museum of Trinity College, shows a striking similarity in the Zoophytes, particularly the fossils named after Goldfuss, *Cyathophyllum turbinatum*, and *C. vermiculare*.

All the fossils found in the Menai Straits, with the exception of these two, are abundant in the lower limestone and yellow sandstone formations of Ireland; and the lithological character of the lowest beds, as given in the section facing p. 17, resembles strikingly the corresponding character of the arenaceous and conglomeritic beds, by which the lower limestones of Hook Point, and other characteristic Irish localities, pass by yellow and white sandstones, grits, and shales, downwards into the typical old red sandstone conglomerate.

The general conclusion which I think may be fairly drawn from the Menai group of rocks and fossils is, that in this district there exists no distinction between Devonian and Carboniferous deposits; but that the entire series of beds, including the red sandstone conglomerates and yellow sandstones at its base, must be considered as a continuous whole, and corresponds in its palæontological character with the lower limestone and yellow sandstone formations of Ireland.

Note to p. 7.—Let the plane of the rectangular axes OX and OY be the plane of the bed, the line OX being parallel to QP (p. 7); and let there be any small rectangle, whose corner is situated at the point x, y previous to the disturbance of the bed by the intrusion of the trap dyke. After the disturbance, by forces in the plane of the bed, let x', y' be the point which was before x, y, and let the parallelogram *oacb* be the figure assumed by the distorted rectangle. Then, if—



$$x' = x + \xi$$
$$y' = y + \eta,$$

it is easy to see the following relations:—

$$oa' = \frac{dx'}{dx}dx \qquad aa' = \frac{dy'}{dx}dx$$

$$ob' = \frac{dy'}{dy}dy \qquad bb' = \frac{dx'}{dy}dy,$$

whence may be derived—

$$oa = dx\sqrt{\left(\frac{dx'}{dx}\right)^2 + \left(\frac{dy'}{dx}\right)^2} = dx\left(1 + \frac{d\xi}{dx}\right) \qquad (1)$$

$$ob = dy\sqrt{\left(\frac{dy'}{dy}\right)^2 + \left(\frac{dx'}{dy}\right)^2} = dy\left(1 + \frac{d\eta}{dy}\right) \qquad (2)$$

$$\cot\theta = \frac{\frac{dy'}{dx}\frac{dy'}{dy} + \frac{dx'}{dx}\frac{dx'}{dy}}{\frac{dx'}{dx}\frac{dy'}{dy} - \frac{dy'}{dx}\frac{dx'}{dy}} = \frac{d\eta}{dx} + \frac{d\xi}{dy}, \qquad (3)$$

and writing—

$$a = \frac{d\xi}{dx}, \quad \beta = \frac{d\eta}{dy}, \quad w = \frac{d\eta}{dx} + \frac{d\xi}{dy},$$

we may remark that a and β are positive for dilatations, and negative for compressions; and that ω is positive for values of θ less than 90°, and negative for values greater.

Let D represent the diagonal of the original rectangle, and d the diagonal oc of the parallelogram; then, since—

$$D^2 = dx^2 + dy^2$$

we find—

$$d^2 = \overline{oa}^2 + \overline{ob}^2 + 2\overline{oa} \times \overline{ob} \times \cos\theta$$
$$= D^2 + 2\,\{adx^2 + \beta dy^2 + wdxdy\}$$

or, if the diagonal, D, of the rectangle make angles λ, μ with OX and OY, we find—

$$\frac{d^2}{D^2} = 1 + 2\,(a\cos^2\lambda + \beta\cos^2\mu + w\cos\lambda\cos\mu),$$

and, extracting the square root—

$$\frac{d}{D} = 1 + (a\cos^2\lambda + \beta\cos^2\mu + w\cos\lambda\cos\mu) \qquad (4)$$

i. e.—

$$\frac{d}{D} = 1 + \epsilon,$$

where ϵ denotes coefficient of linear dilatation of the diagonal of the rectangle.

If this coefficient be represented by the radius vector of a curve, so that—

$$\epsilon = \frac{1}{r^2},$$

it is easy to see that this curve will be a central curve of the second order, whose equation will be—

$$1 = ax^2 + \beta y^2 + wxy. \qquad (5)$$

The axes of this ellipse are the directions of maximum and minimum dilatation or compression, and point out the directions in which the bed tends to break.

1st. If, for example, the disturbing forces were such as to compress or dilate the bed parallel or perpendicular to OX, and to produce no other effect, then the angle θ would continue equal to 90°, and $w = \cot\theta = 0$, and the equation of the ellipse would be—

$$ax^2 + \beta y^2 = 1 \qquad (6)$$

whose axes, OX and OY, are the directions in which these beds would tend to break. This condition would be fulfilled by points situated at a great distance from the porphyry dyke.

2nd. If the distortion produced by the trap dyke were such as to produce no relative motion in the direction OY (which may be supposed, as the pressure of the dyke is lateral in the direction OX), then—

$$\beta = \frac{d\eta}{dy} = 0,$$

and the equation (5) becomes—

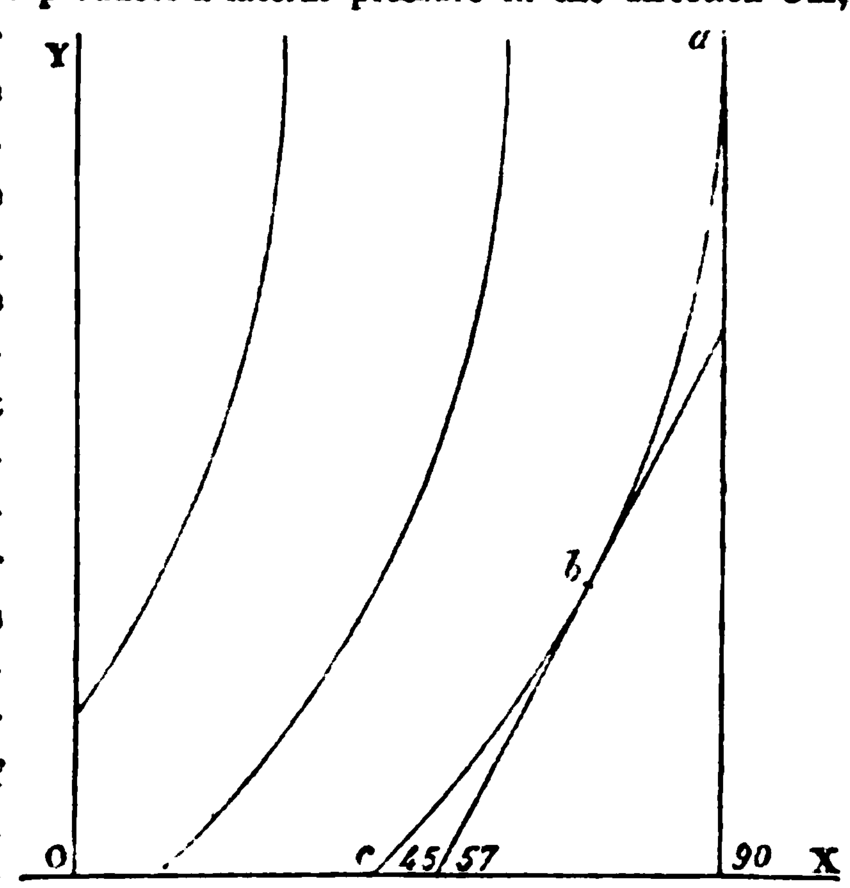
$$ax^2 + wxy = 1, \qquad (7)$$

which is the equation of an hyperbola, whose asymptotes are the line OY and another line, making with OY an angle whose tangent is $-\frac{w}{a}$. The magnitude of this angle will depend on the relative magnitudes of w and a; and at points situated very near the line OX (if we suppose the beds not to slide on the line OX) we shall have $a = 0$; and since, from the nature of the forces acting, the angle θ is acute, w will be positive, and a will be negative, since it corresponds to a compression of the beds. Therefore, at points near the line OX, or porphyry dyke, the angle made by the asymptotes will be 90°, and the line of fracture will make with OX an angle of 45°.

3rd. In general, the direction of the axes, or lines of fracture at any part of the bed, may be thus found:—The angle ϕ, made by the axis of the conic (5) with OX, is known to be given by the equation—

$$\tan 2\phi = \frac{w}{a - \beta}. \qquad (8)$$

The intrusion of the trap dyke produces a lateral pressure in the direction OX, the line OX itself being fixed, or nearly so; and consequently the movement of the particles composing the bed is greater as the distance from OX increases, and is towards the right hand; hence the angle θ is acute, and w positive; a is negative, because it is a coefficient of linear dilatation, corresponding to a compression of the bed; and β is smaller than a; hence $\tan 2\phi$ is always negative, and therefore ϕ lies between 45° and 90°; approaching the former limit in the parts of the bed near the line OX, and the latter limit in the parts of the bed remote from OX.



The effect of the lateral pressure of the trap dykes, acting on the beds placed as

we have supposed, so as to push them obliquely against the porphyry dyke, will therefore be to produce a series of curved fractures, such as *abc*, the direction of which makes with the porphyry dyke OX, at the point of intersection *c*, an angle of 45°; at the point *a*, situated very far from the porphyry dyke, an angle of 90°; and at intermediate points, as *b*, angles lying between these extreme limits.

December 14th, 1853.—"On the Structure of the North-Eastern Part of the County of Wicklow." By J. Beete Jukes and Andrew Wyley, Esqrs.

In revising the six-inch map of the Geological Survey, previously to laying down the results of the work upon the new inch-sheet map shortly to be published, we were led to take a rather different view of the main features of the structure of the north-eastern part of the county of Wicklow from that which has previously obtained.

In stating this view we wish emphatically to remark, that we impute no deficiencies to any of those who had previously examined the country, since without the benefit of their previous labours it is possible we might not have arrived at our present results. The country is one of almost unexampled difficulty: difficulty arising in part from the very complicated and often almost inexplicable structure of the rocks, and in part from the discontinuity of the sections, and the widely separated position of the rock exposures, the intermediate spaces between them being buried under thick and broad accumulations of drift.

We have, however, now re-examined—in many instances for the fifth and sixth time—every exposed portion of rock within the district we intend to describe, and we offer the following results with the utmost confidence in their general correctness, while of the many doubtful localities we believe that we have seen and know all that can, under present circumstances, be ascertained.

The formations to be described are those commonly known as—

I. The Cambrian.
II. The Lower Silurian.

We use these terms as those which have been commonly in use during the last few years, without reference to their abstract propriety, and without expressing any opinion on the controversy which has arisen as to that nomenclature.

I. *The Cambrian Rocks.*—These consist principally of *green and purple grits and green and purple slates*, the beds of each being almost always thick and massive, and those of the grits being frequently very irregular. The structure and appearance of the grits vary greatly. They are of all shades of colour, from bright red to a dull, dark, purplish gray, and from an apple green to a pale gray; the green colour, however, greatly predominating over the others. Their texture, likewise, varies from an exceedingly compact, close-grained sandstone to a coarse granular grit. Sometimes the latter is made up of crystals, so slightly rounded that the rock may be easily mistaken, and sometimes has been so, for an igneous rock. The crystals are of quartz alone, or of quartz in an earthy, feldspathic-looking matrix, and the rock assumes the appearance of a greenstone or a porphyry. Flakes of white mica, however, are commonly disseminated here and there through all the grits; and these, together with the rounded angles of the crystals, and the bedded appearance of the rocks must be sufficient to guard the observer against error. In no part of the formation have we ever observed anything that could be called a conglomerate or a breccia.*

Some of the more purely siliceous grits often seem to be on the point of passing into quartz rock, and are, indeed, scarcely to be distinguished from it, except, perhaps, by their colour, by a slight difference in hardness, and by the absence of that utterly jointed structure so characteristic of quartz rock.

All the grits are, however, very hard, and some of them "tough" also, so that their fracture is excessively difficult.

The slates vary in colour as much as the grits, and assume exactly similar hues, except that in addition to the reds, greens, and grays, they sometimes put on an olive-brown colour, varying between greenish and yellowish. The olive-brown colour is probably a superinduced one. It is usually confined to those slates and grits lying close to the quartz rock, and seems to be due either to the action, whatever it was, that changed the sandstone into quartz rock, or perhaps to subsequent infiltration; the beds lying near the

* Near Howth Harbour are small patches of a conglomerate or breccia plastered against the cliff in Poulscadden Bay; but we have considerable doubts as to the age of these patches, and believe they are not belonging to the Cambrian rocks, though made up of their *debris*, and are rather inclined to refer them to the age of the old red sandstone.

hard and unyielding quartz having been more broken up, and thus rendered more permeable to atmospheric moisture than those at a distance. The slates, also, assume every variety of texture, from a mere earthy "cleaved sandstone" or "flagstone" to a very fine-grained, smooth roofing slate. Many of the more irregular of the slates might, perhaps, with more propriety be called "shale," or "schist." They often look chloritic, and have a soapy touch.

Alternations of red and green, and other colours, often occur in the slates; and these alternate bands most commonly, but *not always*, mark the stratification. It is important to recollect that the changes of colour do not always coincide with the planes of stratification (as proved by beds of grit and alternations of texture), and that they sometimes even have no relation at all to each other, but cross at right angles, or in any other direction.

Throughout the Cambrian district of Wicklow there is a remarkable absence of any igneous rock. The only two localities we know where such rocks appear is, one at Greystones, where a dyke of a highly hornblendic crystalline greenstone cuts through the low cliff of Cambrian grits; and the other of a very crystalline epidotic greenstone, a little south of Roundwood.

In addition to the ordinary grits and the slates, the Cambrian rocks of Wicklow are characterized by an abundance of quartz rock. This is ordinarily of a yellowish-brown or yellowish-white colour, varying in texture from compact to granular; the grains, as in all quartz rocks, looking as if partially run together at the edges. The quartz rocks have every possible gradation into the grits.

The ways in which these several kinds of rock are combined and interstratified one with the other are so very various that it is very difficult to throw them into groups, or to assign to them any regular order of sequence that shall be true for the whole district.

Their total thickness seems to be enormous, since that shown, to all appearance, and without any reason for doubt, in one or two several localities exceeds many thousand feet; and if these are really different parts of the same series, the total thickness must reach at least twenty or thirty thousand feet.

From the difficult nature of the country it is with much doubt and hesitation that we venture to suggest, rather than to declare, the following two groups, beginning with the lowest:—

1. The Ashford and Devil's Glen group, characterized by the

relative abundance of massive grits, and the more frequent occurrence of red slates. It has but little quartz rock associated with it.

2. The Bray Head and Sugarloaf group, in which the slates are relatively more abundant than the grits, the green colour much more predominant than the red, and the quartz rocks assume their most abundant and important features.

We should likewise be inclined to consider the obscure fossil zoophyte, named by Professor Forbes "Oldhamia," after the former distinguished Local Director of the Survey, Professor Oldham, as characteristic of this group.

II. *The Silurian Rocks.*—We wish, in describing this formation, to confine our observations mainly to its base, or to the lowest beds in the county of Wicklow. Whenever these can be certainly ascertained, they have been invariably found to consist of what would be ordinarily termed "black slate." Very often this is really black, and sometimes carbonaceous looking, so as when decomposed to resemble coal shale. More frequently, however, the slates are dark bluish gray, or dark iron gray, looking really black only when they are wet. They are always very fissile, and commonly very brittle and rotten, breaking immediately into small thin plates, so that except from a quarry it is difficult to get and preserve a slab of them larger than the hand. They are almost always interstratified with thin, iron-gray, siliceous grits, forming little beds of an inch or two in thickness. These grits sometimes occur as lines of lenticular-shaped nodules, instead of continuous beds. Beds of trappean feldspathic ash, generally of a pale greenish-gray colour, are sometimes associated with the black slates, even to their lowest beds. Higher up in the black slates there often occur bands of slates similar in mineral character, but coloured brown or yellowish, or sometimes assuming an olive colour, and they then become very similar to the olive-coloured slates in the upper part of the Cambrian rocks; the colour being probably in each case due to some subsequent action of decomposition.

Above these again, but very much higher up in the series, occur bands of red or purple slate, and even of red and green slate, which can scarcely be distinguished in hard specimens from some of those of the Cambrian rocks. There are, however, slight lithological distinctions; and their immediate association with the black slates obviates the possibility of any important mistake being made be-

tween the two formations. The most striking distinction between them, and one which appears invariable, is, that the Cambrian rocks never contain any *black slate*, and the Silurian never have any thick, massive, green and purple grits.

In describing the actual position of the component portions of the two formations, and their relations to each other, it will be necessary to commence in the neighbourhood of Rathdrum, and proceed thence northwards to Bray and Killiney.

A few miles west of Rathdrum is the valley of Glenmalure, through which flows the river Avonmore. On the flanks of Glenmalure we see resting on, or abutting against, the granite a dark gray mica schist, which, as we recede from the granite, rapidly passes, apparently by insensible gradations, into the ordinary black, blue, or dark gray slate of the Silurian formation. This, towards the east, becomes variously associated with many igneous rocks, but it preserves, as to its aqueous portion, the same lithological type from the granite to the sea. The dark slates are frequently interstratified with grits, which in some places thicken out to two or three feet, and with thin bands of slates of paler colour than usual; but it would not be possible on this line of latitude to draw any good boundary line in the series, so as to say there was any essential difference of character in the rocks above and below it. It is true they put on an altered appearance when they approach the granite hills, but so they do in the very heart of the formation a little south of Rathdrum, at Ballinaclash, where a small boss of granite protrudes through them; and in each case they suffer a similar kind of alteration, namely, the development of mica.

If now we travel north from Glenmalure along the foot of the granite hills, and examine each valley and brook as we proceed, we shall always find exactly the same dark gray micaceous schist resting on the granite, and passing in a very short distance to the eastward into black or blue clay slate.

This is true for the whole range of the granite hills from Glenmalure to Killiney; it is also true southward of Glenmalure as far as the granite extends. In proceeding north, however, we should find that when we arrived at the neighbourhood of Annamoe and Roundwood we should no longer meet with these dark-coloured slates occupying the whole ground eastward from the granite to the sea; but that, after passing a certain straight line running nearly

N. N. E., parallel for the most part to the granite, and at a distance of about two or three miles from it, we should find ourselves among the Cambrian rocks, consisting of massive grits and slates, with much quartz rock. If we set to work to discover how these Cambrian rocks came in, we should have great difficulty in arriving at any conclusion by examining the line of country just mentioned, from the defect of any good natural sections; but a very careful examination of the southern border of the Cambrian rocks between Annamoe and Ashford would enable us to see a distinct and very wide unconformability between the two formations, and that the black Silurian slates were in reality resting on the upturned edges of the Cambrian rocks.

In the neighbourhood of Rathdrum, the strike of the Silurian rocks—as shown by detached dips, and by the lines of their associated grits and contemporaneous trap rocks—is about N. E. by N.; the dip being almost invariably at a very high angle, and most commonly towards the south-east. In the Cambrian rocks, however, west of Ashford, about the Devil's Glen, and in all the neighbouring country, the strike is almost invariably east and west, and the dip to the northward, at angles varying from 60° to nearly 90°. The common boundary of the two formations is at one part remarkably undulating, with deep bays and projecting promontories; the black slates of the Silurian formation occupying the ridges of the hills and higher grounds, and the red and green grits of the Cambrian being seen only in the valleys and flats.

In the ridge of Ballycullen, which runs south of the Devil's Glen, about two miles west of Ashford Bridge, we have a long island or promontory of black slate (we cannot say exactly which), running about N. E. by N., nearly three miles long, and not more than half a mile in width. There are many small quarries and cuttings in this black slate, but it is difficult to make out its stratification except at the cutting of the road from Ashford to Annamoe. The beds here are for the most part vertical; but in one larger exposure than usual, they are seen, by the occurrence of grit bands, to be violently contorted and crumpled up, the flexures being so excessively sharp and sudden as easily to be overlooked unless very well exposed.

In the valley on either side of this ridge, and for a certain distance up the slope of its eastern side, are seen many knobs and hum-

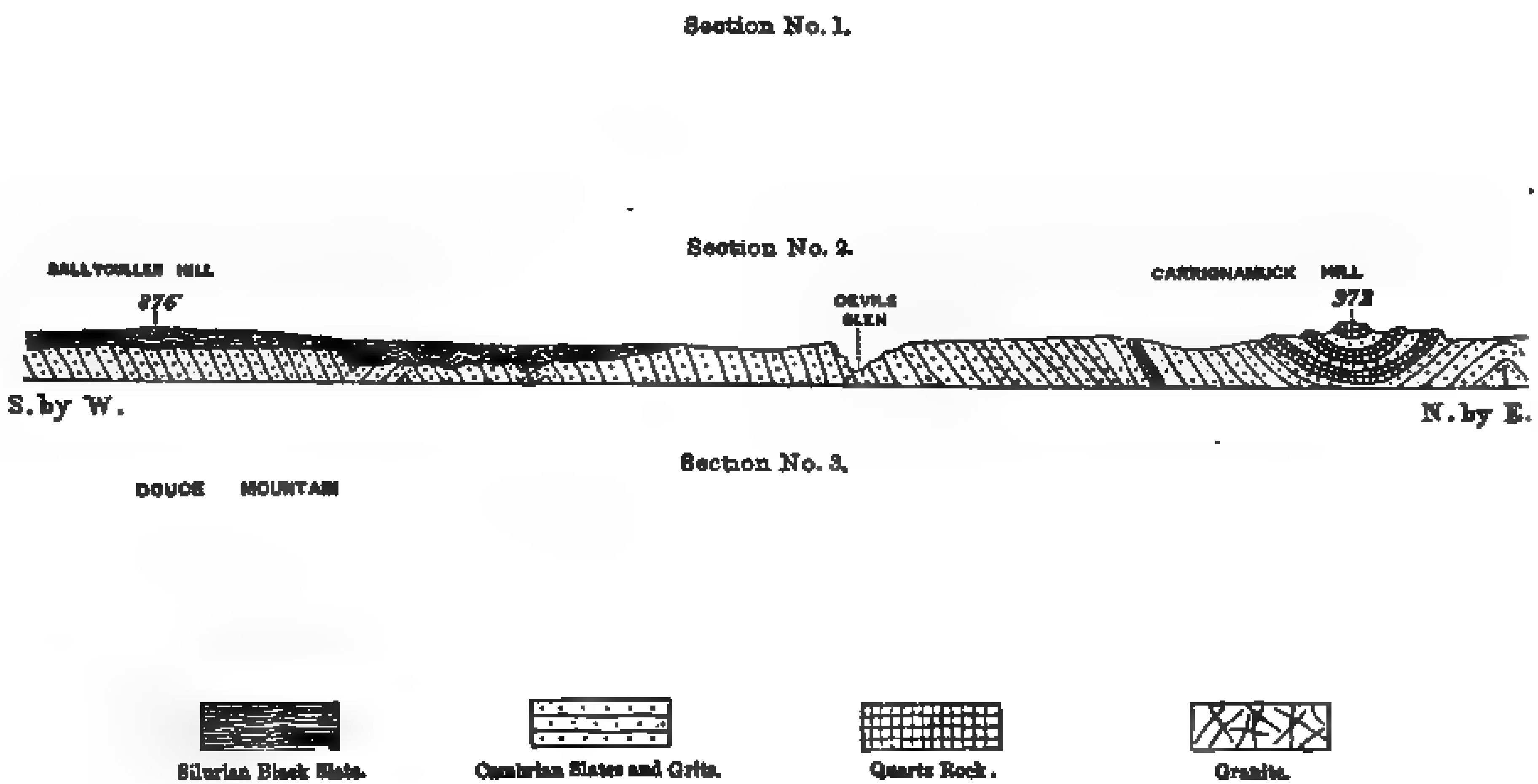
mocks of massive green and purple sandstone, with interstratified beds of red and green slate, every one of which have a strike varying from E. N. E. and W. S. W. to W. N. W. and E. S. E., or striking directly *at* the boundary of the black slates. The dip (see Sections Nos. 1 and 2) is nearly, if not quite, invariably to the northward, at an angle never less than 60°, and the rocks have all the appearance of striking through the base of the hill, and having their edges covered up by the contorted and crumpled beds of the black slate on the upper part of the ridge.

West of the Ballycullen ridge is a flat, boggy piece of ground, about a mile in width, exposing rough knobs of Cambrian rock dipping at high angles to the north; and west of that again rises another high ground called Moneystown Hill, on the flank of which the black slate again sets in at about the same level above the sea as in Ballycullen ridge, namely, about 700 feet. At one point here, by the road at the junction of the townlands of Moneystown (North and South) and Kilmullen, the unconformity is even locally apparent, as the black slates may be seen on one side of the road dipping at an angle of about 10° to the westward, while on the other side the green and purple grits dip S. E. at 60°.

Passing over the northern end of Moneystown Hill, we again come upon a flat, where bosses of the Cambrian rocks show themselves; this flat being closed to the south-west by the high land of Trooperstown Hill, whence a ridge runs northwards to Castlekevin; the whole of the ground above a certain level being occupied by black slate as before.

At Castlekevin we are at the southern extremity of the straight, or nearly straight, line of boundary before described, running thence by Roundwood to Killiney.

In following along this line of boundary we have only one tolerable section of the two formations exposed,—that, namely, in the bed of a small brook on the flank of Douce Mountain, at a place called Glasnamullen (see Section 3). We have here, below the Enniskerry and Roundwood road, the Cambrian rocks in their most characteristic form, a good deal contorted, but dipping on the whole to the westward at angles varying from 30° to 80°. Above the road they dip still principally to the westward, so far as can be seen, but with occasional rolls to the southward, until about a quarter of a mile above the road the black slates come in quite suddenly, and in a po-



Sections to illustrate the Paper on the Structure of the North-Eastern Part of the County of Wicklow.
By Messrs. Jukes and Wyley.

sition closely approaching to the vertical. The upper sides of their beds, however, appear to be to the westward; and it is believed that the westerly dip is continued for some distance till a considerable thickness of black slate is accumulated before the beds rise again on to the flanks of the granite. For a space of about a third of a mile from the granite they dip easterly at angles of 20° or 30°, and have assumed the ordinary form of mica slate. Their lowest beds down in the brook are interstratified with some peculiar varieties of feldspathic ash or similar rocks.

In the valley of the Cookstown river, near Enniskerry, the black slates of the Silurian formation are suddenly deflected widely from their previous boundary, running from Enniskerry down to a little beyond the lower bridge of the Dargle glen, about a mile from Bray, just below which bridge, in the grounds of a cottage residence called Riversdale, rocks of the Cambrian formation again make their appearance. At the lower end of the Dargle glen, ash beds, exactly similar to those before mentioned, may be seen irregularly interstratified with the black slate. This projecting tongue of black slate is believed to be brought in by a large fault running nearly east and west, and having a downthrow to the north. Cambrian rocks may be seen at St. Kevin's Well again, to the north of this tongue, from which point the boundary of the Silurian rock is believed to resume its north-easterly course to the shore south of Shanganah, but its actual place cannot be determined, as the whole rocks are buried in drift.

In attempting to sketch the structure of the ground formed by the Cambrian rocks that lie between the boundary thus roughly described and the sea, it will be necessary to return to the vicinity of Ashford.

The red slates of Glenmore Castle, and the flanks of the Ballycullen ridge, dip to the northward, and pass under the massive grits and slates through which the ravine of the Devil's Glen has been excavated. These likewise dip almost invariably to the northward, except about the Waterfall, where they are sharply undulated in various directions. Taking the Devil's Glen as the centre, over all the country from Ballyduff Bridge on the west, through Ballycurry Hill and Rathmore to Castlegrange on the east, a distance of more than four miles; and from Ballycullen on the south to Dunran Hill on the north, a similar distance of four miles,—the prevailing dip is

steadily to the northward, often at very high angles, and sometimes absolutely vertical. There are, it is true, many small local flexures to the east or west of north, and some places where a southerly dip is possible, although it is not certain; it is true, also, that where the beds are vertical their upper surfaces may in some places be to the southward as probably as to the northward; still the main fact remains of there being a vast thickness of rock here striking east and west, and dipping mainly to the north. The same fact becomes evident on tracing the run of the quartz rocks. At Rathmore, for instance, there are two or three narrow, interrupted beds of quartz rock, running nearly east and west for about two miles, all the dips near them being to the northward. These beds end suddenly to the eastward in a very remarkable way, as exactly in the strike of them, across one narrow field and a road, are seen beds of slate and gritstone, with the same strike and dip, but utterly devoid of quartz rock. They end to the westward in an equally abrupt manner near the village of Killiskey, but to the north-west of that, quartz rock again sets in; and on the side and summit of the Hill of Carrignamuck huge ridges and bosses of quartz rock, with slates peeping out here and there between them, come in in the most perplexing way, running in all sorts of directions, stopping out suddenly and then recurring again, so that we found it a hopeless task, after some days' labour, to disentangle the confusion of their minute details. After passing over this hill, however, quartz rock again appeared in the marshy flat beyond, interstratified with slates and sandstones, the whole dipping very steadily to the north at 60°. These quartz rocks, however, again end suddenly in the townland of Knockfadda, and are nowhere seen to the westward, where the rocks for some distance seem to have suddenly altered their strike, dipping at angles of 50° or 60° to S. E., E., and N. E.

It is remarkable that these two breaks in the continuity of the quartz rocks occur about in the direction of the projecting promontories of black slate of Ballycullen and Moneystown, if the general bearing of those features were prolonged. This prolongation also would have a bearing about N. E. by N., parallel to the general strike of the Silurian formation farther south. It is probable, therefore, that the interruptions and dislocations of the quartz rocks may be in part connected with the occurrence of great lines of intense disturbance and dislocation affecting the Cambrian rocks in a

direction across and nearly at right angles to the strike that had been formerly communicated to them by elevatory forces acting before the deposition of the Silurian beds.

It is clear that the Cambrian rocks must have been elevated, and must have suffered from denudation very largely, before the deposition of the Silurian rocks. If any contortions were produced in them at that very ancient period by forces acting in one direction, and if at a long subsequent period new forces of disturbance were brought into play, producing contortions and dislocations having no connexion with or relation to the former ones, it may well happen that it may now be almost utterly impossible for us to unravel the perplexity and confusion thus produced, even if we had every portion of rock bared and washed clean for our inspection. When we recollect that of such a Chinese puzzle we have only a fragment here and there exhibited to us, it may be a good warning to us to hesitate before we assert any decided conclusions as to minute points of detail.

Taking, however, the district now described as our base line, and assuming the prevailing inclination of the beds to the north to be real as well as apparent, the rest of the Cambrian district may be briefly described as follows:—

In the high grounds of Ballinahinch, Tithewer, and Drumbawn, west of Newtownmountkennedy, there are a few occasional lines and knobs of quartz rocks striking about N. E. and S. W.; the dip of the rocks varies from N. W. to S. E., usually at angles exceeding 40°; and we believe that there is a rather larger undulation of the beds here, producing one or two synclinal and anticlinal curves, and that a synclinal in Ballinahinch Hill brings up the beds that had previously dipped north, making them rise in that direction nearly as far as the river of Altidore, where the dip becomes again N.W. One or two sharp flexures, on a smaller scale, then appear to take place; the beds finally plunging to the northward, under the two Sugarloafs and Bray Head.

As this northern district is an interesting one, and has already been the subject of discussion before the Society, we will here venture to give our present views of its structure in a little more detail.

The ridge of quartz rock which forms Walker's Rock is traceable nearly north and south for about three miles just east of

Powerscourt Deerpark, dipping, as far as can be ascertained, to the eastward, at an angle of 70°. East of this the grits and slates suffer some local flexures, but finally plunge east under the Great Sugarloaf. This hill is one great bed of quartz rock, the base of which we believe to be marked by the ledge that occurs on the west side of the mountain, and its upper surface by a patch of unaltered gritstone with slate, which minute search discloses near a gully on its eastern slope. To the north the beds seem to be all cut off by a fault, which we believe to run down the glen from near Coolakay to Kilmacanoge, and thence through Kilruddery Deerpark to Windgate.

On the south side of the Sugarloaf the beds appear to curve round to the east and dip north, striking easterly by Kilmurry North, and then curving round and striking north through Kilruddery Deerpark. Here we can see them on the higher ground dipping west under the main quartz rock of the Little Sugarloaf.

This position of the beds of the Sugarloaf Hills supposes them to form a sort of rude basin, the quartz rock of each Sugarloaf being the same mass, dipping east in the Great one, and west in the Little one, with a thin patch of slate lying concealed under the drift in the hollow between them. This great bed of quartz being cut off by the fault before mentioned (which is an upthrow to the north), and the ground north of the fault being lower, forms a smaller tongue-shaped mass running as far as Hollybrook, with the lower beds rising from under it on both sides; and we believe it to be the same bed that forms the massive quartz rock of the summit of the hill of Carrigoona Commons, and possibly also the same with the massive quartz on the northern summit of Bray Head.

The smaller lines and ridges and spots of quartz rock we believe to be parts of beds that all lie underneath this large one, and show themselves here and there as they are brought up and exposed by the various flexures and contortions of the strata.

Bray Head, although at first sight very simple in its structure, and consisting of a huge mass of slates and grits, with interstratified quartz rock, all dipping to the north, yet presents many difficulties for explanation when minutely examined. Of the eight beds of quartz rock which strike regularly over the top of the hill in parallel lines, running N. E. and S. W., two only come down to the sections on the coast and in the cuttings of the railway, where the dip

and strike seem remarkably regular and persistent, being almost invariably to the N. N. W., at 50° or 60°. We have been led to doubt whether the appearances here are not deceptive, and whether there may not be a great flexure (or perhaps even more than one), the beds being bent back upon themselves, so as all now to appear to be dipping to the northward. If this is not the case, it appears possible that some of the beds may be cut off and concealed by the action of a fault running obliquely along the eastern slope of the hill; and some such fracture appears probable from the examination of the eastern end of the southern line of quartz rock. In either case, we believe that the large mass of quartz rock on the northern slope of the hill, and which we are inclined to identify with that of the Sugarloaf, merely rests on that slope of the hill, and is cut off to the north by the east and west fault, mentioned before as running by Enniskerry, and bringing in the tongue of black slate. This fault must be a downcast to the north; and this quartz-rock bed will then be that which is shown here and there about the town of Bray, and appears to dip to the eastward, and strike the sea-coast somewhere north-east of the town, being buried in that direction under the drift.

We have now to describe briefly three outlying districts of Cambrian rock, occurring within the limits of the space we have intended to discuss.

The first of these is in Carrickgollogan, or Shankhill. The quartz rocks and lighter-coloured slates of this hill we believe to belong to the Cambrian formation; they are surrounded on one side by mica schist, and on the other by black slate, both of which we believe to be Silurian.

The second is a district south of Roundwood, where a small tract of red and green slates and grits, with one boss of a kind of greenstone, is likewise surrounded by black slate. Some of the altered Cambrian rocks of this locality assume some of the external characters of serpentine.

The third district is much larger and more important, being the range of Carrick Mountain, which, with the two minor ridges of Cronroe and Ballinastraw, runs nearly N. E. and S. W. for six miles, beginning at Ballinalea, a little south of Ashford Bridge. The quartz rocks of this range are very bold and massive, forming often great crags and ridges of bare rock rising from 20 to 60 and 80 feet

above the adjoining ground. Slates and grits of red, green, and olive-brown colours may be indistinctly observed here and there between them, and wrapping round their ends, and in a few places enough of these are exposed to give us an observation for the dip of the rocks. This was generally found to be at a very high angle, either to the N. W. or S. E., more often the latter; the angle usually greater than 60°, and oftener approaching the perpendicular.

Black slate may be observed in the cuttings of the roads between this ridge and the rest of the Cambrian district, but never in sufficiently large quantity to afford any clue to its real inclination, or relation to the rocks below. The N. W. boundary of this black slate, however, runs in such a very straight line for several miles, and it forms so marked a feature in the shape of the ground, that we were induced to consider it as a line of fault. This conclusion was strengthened by the fact that the Cambrian rocks of Carrick Mountain do not at all resemble those of the immediately adjacent country, but much more nearly those of the neighbourhood of Bray Head and Kilmacanoge; in addition to which, Oldhamias have been found in those three places, and in no other locality that we are aware of. If, however, the rocks of Carrick be really the upper part of the Cambrian formation, and those of Aghowle and Ballycullen be the lower, the strike of the first being N. E. and S. W., and the strike of the latter E. and W., in each case over a district of some miles in extent, and running side by side with each other, it is clear there must be a dislocation of very great magnitude between the two.

As the two principal results of this paper, we wish to call attention—

First, to the unconformability between the Lower Silurian and Cambrian rocks.

Secondly, to the position of the stratified rocks, taken *en masse*, with regard to the granite.

1. In north Wales we have the lower Silurian rocks, principally dark gray and black slates, with many contemporaneous and intrusive feldspathic and hornblendic traps, resting apparently quite conformably on a great series of red and green grits and red and green slates, to which series the term Cambrian has been restricted by the Survey. These Cambrian rocks are, in North Wales, quite unfossiliferous so far as is known, but they agree in all their mine-

ral and lithological characters, except in the occurrence of quartz rocks, precisely with what we have called Cambrian in Wicklow. These Wicklow Cambrians are likewise unfossiliferous, with the exception of the remarkable fossil zoophyte, Oldhamia.

In North Wales it is rather difficult to draw any good physical boundary between the two formations. The unconformity between them in Wicklow, however, establishes a good physical break and interval between them in that locality. That it is a local unconformability appears probable, because when we go into Wexford it possibly disappears, though even there, there are certain evidences of unconformability in particular places, and presumptive evidence in favour of it when the rocks are viewed on the large scale, inasmuch as, though striking in the same direction, and dipping at the same angle, the rocks which in one place lie immediately under the black slate appear different from those which underlie it at another.

You will see that we are here on the traces of questions which must have a direct bearing on the general classification of the lower palæozoic rocks.

2. The position of the stratified rocks with regard to the granite is very interesting, as tending to modify the ideas with regard to the physical action of this rock, which, if not now prevailing, have only just ceased to be universally entertained. It was always thought that the eruption and elevation of a great range of granite invariably brought up upon its shoulders the lowest formation of the neighbourhood, and flung off the upper ones to a greater distance from its flanks, in proportion to their newness.* In North Wicklow, however, we see, according to our present results, that the granite has in no instance the lowest formation, namely, the Cambrian, in contact with it, in no instance brings any portion of it up upon its flanks; but on the contrary, that the Cambrian rocks either dip towards the granite when they approach within a couple

* I may remark here, that I had long ago been suspicious of the fallacy of this notion, and been inclined to attribute the elevation of rocks generally to a great widely-acting force, most probably the action of great heat, of which the production of igneous rocks was one of the local symptoms; but to look on the actual outburst of igneous rock as tending to produce depression rather than elevation in its immediate neighbourhood, except so far as the mere puckering and crumpling of the beds directly in contact with them are concerned.—(*Note by J. B. Jukes.*)

of miles of it, or pay no regard to it at all; and that the Silurian rocks which rest upon the granite have their beds tilted up by it only when very near it, and then at comparatively low angles, while a mile or two off they are almost invariably vertical, much contorted, but seem to have a general tendency to plunge headlong in the direction of the granite. It seems as if the elevation of the granite and its outburst had left a great hollow or cavity, as it were, running parallel to its present general direction, and a little distance removed from it, and that the rocks had sunk bodily into this cavity, suffering greatly from lateral pressure, doubtless, during the process, while rocks still farther removed had remained wholly or comparatively unaffected.

Although it is beyond the limits of this paper, we will just add, that the position of the rocks on the Kildare side of the granite confirms these conclusions. The lowest rocks are farthest removed from the granite; and, notwithstanding many sharp flexures which are seen here and there, the general dip of the whole is towards the granite, except immediately on the flanks of that rock where the beds are bent up against it.

Postscript.—Since the above was written we were induced to examine the little island of Ireland's Eye. In that small space we find a very good example of the two formations, Cambrian and Silurian, in positions which almost necessarily involve their unconformability, though that is nowhere actually apparent in any one spot. Along the north of the island stretches a bold ridge of quartz rock, which on the western side is a good deal interrupted and intertangled with slates and unaltered grits. South of this, on the western shore, we have a considerable space occupied by red and green slates and grits, greatly contorted, but on the whole striking east and west, and dipping apparently to the south. In this direction there come in, about the middle of the island, beds of black slate with thin grits, bands, and nodules. These are likewise contorted, but on the whole dip nearly south for a considerable distance, till on approaching the south end of the island they rise suddenly in that direction, at a very high angle; and there comes out from under them a mass of green slate, with green grits and some quartz rock. So far there is no direct evidence of unconformability; but on the east side of the island the black slates are continued much further

north than their line of boundary on the west side, and are seen well exposed in the cliffs forming all the higher ground, and continuing till they rest against the quartz rock, which forms the northern ridge of the island.

It thus appears that the red and green slates, and grits, which on the west side of the island come in above the quartz rock, and are seen striking across the low beach in bristling rocks for several hundred yards south of the quartz rock, are completely overlapped and concealed by the black slates on the east side of the island; and nothing is allowed to appear through these except the harder and loftier ridge of the quartz rock.

The black slates here appear generally to be dipping to the south here, away from the quartz rock; but they are frequently contorted, and we have long learned to attach very small importance to the appearance of *dip* in such yielding beds as the black slate when they have at all been affected by disturbing forces. The relations of such beds to the surrounding rocks can only be with certainty ascertained when large districts have been carefully examined, and the general outlines and behaviour of the rocks completely determined.

Mr. J. W. Salter informs us that palæontologically the Silurian rocks of Wicklow and Wexford represent the "Bala beds" of North Wales, and that there is among them no palæontological representation of the still lower group of the "Lingula flags." Simultaneously, then, with the unconformability between the two systems of rocks, there is a gap in the sequence of groups which exist elsewhere. The elevation and denudation of the Cambrian rocks, then, which is the proximate cause of the unconformity, may have occurred in the interval belonging to the "Lingula flag" period.

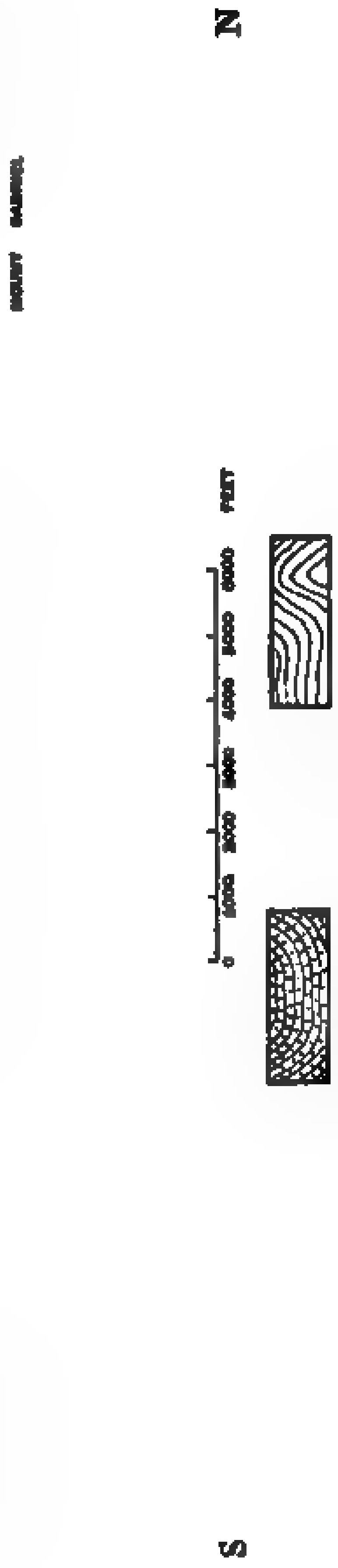
January 11th, 1854.—Thomas Dawson Triphook, Esq., read a Paper "On the Geology of the Neighbourhood of Skull, in the County of Cork, accompanied by a Geological Section from the eastern end of Long Island to western boundary of Mount Gabriel Wood."

Long Island is one of those numerous small islands on the south-west coast of Cork, forming a natural breakwater to Skull Harbour,

and on the western side is about nine miles from Cape Clear and the Fastnet Rock. Mount Gabriel is about 1329 feet high, the highest hill in this part of the country: it is a part of one of the long peninsulas running towards the south-west, and forms one side of Dunmanus Bay, on the other side of which, separated by a similar peninsula, is Bantry Bay.

There is a large gap or ravine in Mount Gabriel, at about half the height, through which a new road has been carried, and there appear on its side and bottom scratches or striæ, similar to those mentioned by Mr. Lyell as occasioned by the passage of icebergs, and they seem worth the attention of a geologist, as being the only passage through which, on the emergence of land, such bodies could have passed for a considerable distance. Not far from the top of the hill, and close to the line of section, is a small lake of about six or eight feet deep, surrounded by cliffs, where good observations of dip can be had.

The rock represented in section consists of two distinct varieties of sandstone; the one commonly called purple slate, and the other green grit, with their corresponding shales. Though the rock is abundant, it is difficult to obtain quarries for building materials: first, there are so few jointed beds; secondly, the stones are so laminated from cleavage that few, excepting large masses, can be got



Section to illustrate Mr. Triphook's Paper on the Neighbourhood of Skull.

out above six or eight inches thick. The green grit can be chiselled or cut for masonry, but for this purpose is not easily obtained, though this rock is much better jointed than the purple grit. It has been analyzed in the Laboratory of Trinity College, Dublin, and found to consist of—

Silex,	94
Oxide of iron and alumina,	4
Alkali,	2
Lime,	Trace.

The cleavage is generally a few degrees from the vertical; and it is exceedingly difficult in some places, from the compactness of the beds on each other, to distinguish the true dip of the beds, especially when the latter are nearly vertical; but when flat, the cleavage seldom or ever runs through two adjoining beds in the same direction: hence this may be used as a means of distinguishing two beds. The shales are also of importance in this respect in these rocks, together with hard nodules, which stand out from the face of the rock after exposure to the weather.

The country appears to have undergone very considerable denudation; it is consequently rare to discover any anticlinal axis which has not the top of the upper beds completely cut away, and the occurrence of such an axis is only recognised in some places by the sudden reversion of the dip.

The principal minerals are quartz, chlorite, micaceous iron, malachite, copper pyrites, iron pyrites, sulphate of barytes, with bog iron and wad. Of these the quartz veins with chlorite are very abundant. Generally associated with chlorite is the micaceous iron; and in most of the quartz veins, when these occur together, they are generally looked on as taking the place of copper ore, which, though of excellent quality in this country, is deficient in quantity and greatly scattered.

No fossils, that I am aware of, have been discovered in this district; but, as regards position, these rocks lie under mountain limestone and magnesian limestone at Cork, to which place they continue; but as they go eastward the purple slate becomes of a red colour, lying, as in section, under the green grits, over which, and when they are wanting on the red slate, the limestone is imposed; also, as they approach Cork, they assume more the appear-

ance, especially in the green grits, of a conglomerate of hard nodules and cementing matter, as though the heavier particles were first deposited in shallower water, while the finer were carried out to the deeper towards Cape Clear.

There is no limestone within thirty miles of the line of section; consequently the lime is imported, and sea-sand is used for agricultural purposes in its place.

The contortion (shown on the section) under water in Long Island channel is seen at the western end of the island, and in another to the westward of it; so that the line passing through them parallel to the strike on the island and main land would place the same contortion, if carried on, as is probable, as shown in the section, and by the arrows and colour on the map.

The strike of the rocks in this country is very uniform, generally from E. and W. to E. 10° N.

The heights are taken from the Ordnance Map.

The mines of the Audley, Coosheen, and Crookhaven Companies are adjacent to the line of section, and occur almost invariably at the junction of the green grits and purple slate; the ores being seldom or ever found in the latter, and, when they are, the gangue is generally green grit and quartz.

I have calculated the thickness of the purple slate and the green grit to be the following, in feet:—

Purple slate, ...	8864
Green grit, ...	1581

For building material, the red slate about Cork is selected in preference to the green grit.

January 11th, 1854.—Professor Haughton communicated the following Notices of Fossils from the Carboniferous Limestone.

1. **Tragos semicirculare**, *M'Coy*.—This fossil is described by Professor M'Coy (Synopsis Carb. Foss. Ireland, p. 196, pl. xxvii. 8) as a zoophyte, probably allied to the family Spongiadæ. My attention was directed to it by Captain Jones, who, from a comparison of a specimen from the Kildare limestone, in Dr. Griffith's collection,

with his own collection of fishes' teeth from the Armagh limestone, was led to believe that it should be referred to the vertebrate, and not to the zoophytic, class. On a comparison of Captain Jones's specimens with Dr. Griffith's and another from Kildare, in the Museum of Trinity College, I believe that the *Tragos semicirculare* is identical with the *Cladodus striatus* of Agassiz.

2. **Atrypa hastata,** *Sow. sp.*—Two specimens of this fossil, showing the colouring of the original shell, are figured in the accompanying plate (Figs. 1, 2). The colouring matter appears to have been distributed in diverging rays of variable breadth: it appears on the figured specimens as a dark gray shading on the whitish blue of the shell. These specimens were presented to the Museum of Trinity College by George Dawson, Esq., and were found by him in the neighbourhood of Drogheda.

3. **Orthoceras unguis,** *Phil.*—Two specimens of this fossil are figured in the annexed plate: one (Fig. 3), found by the Rev. John Quarry at St. Doolagh's, Dublin; and the other (Fig. 4) by myself, at Llanedwen, Anglesey. The figures represent sections, showing the internal structure of the chambers and siphuncle; and from an inspection of them it appears that the siphuncle is beaded. From the specimens which I have had an opportunity of examining, I am inclined to believe that there is no sufficient reason for considering *Orthoceras arcuatum*, *Phil.*, to be distinct from the present. Mr. M'Coy has separated both these species from *Orthoceras*, and proposed for his new genus the name *Campyloceras*, derived from the curved outline of the fossil.

4. **Orthoceras fusiforme,** *Sow.* — From numerous sections of this fossil I have ascertained that it is provided with a beaded siphuncle, differing in no respect from that of *Orthoceras unguis;* it possesses, also, the curved outline of the latter, as is well shown by some beautiful specimens in the College Museum, found at Millicent, Kildare. I am strongly inclined to adopt the opinion that it should be considered the same fossil. Of the two figures given of it by Mr. Sowerby (Min. Conch., vol. vi., pl. 588), one would be called *O. unguis*, and the other *O. fusiforme*, by most geologists who recognise the difference between them. Mr. M'Coy has formed it, together with a new species (*ventricosum*), into a genus (*Poterioceras*), distinct from *Orthoceras*. If any new genus be formed, it should be one named from the beaded structure of the siphuncle,

which is a fundamental characteristic. But it appears sufficient for all practical purposes to consider these orthoceratites simply as a subdivision with a moniliform siphuncle. From the *Actinoceras*, however, they appear to be distinguished by their curved outline.

5. **Producta gigantea**, *Sow.*—From an examination of a great number of specimens of these fossils *in situ* at Vaynol Wood and Bryn Adda, Caernarvon, I am satisfied that it should be considered the same as *Producta Scotica*, *Sow.* The striation near the beak is the same; and it is only in large specimens, and at a considerable distance from the beak, that the longitudinal digitiform ribs, characteristic of the *P. gigantea*, make their appearance. Professor Phillips has already proposed to unite *P. Scotica* and *P. hemispherica*, *Sow.*, under the name *P. aurita;* to these should be added *P. gigantea.*

The specific name *Scotica* should perhaps be retained, as being that under which most of these fossils have been described.

AT THE

ANNUAL GENERAL MEETING

HELD ON

WEDNESDAY, FEBRUARY 8th, 1854,

THE PRESIDENT,—JOSEPH BEETE JUKES, ESQ.,

IN THE CHAIR,

The following Report from the Council was read and adopted:

THE Council present to the Society the following Report for the past year:

During the year *seventeen* new Members have been added to the Society, viz.:—*Life Members:*—Richard Purdy Allen, Esq.; Edward Barnes, Esq.; Professor Edward Forbes, F. R. S., President of the Geological Society of London; Professor Harkness, F. G. S.; William Bullock Webster, Esq.; and Andrew Wyley, Esq. *Annual Members:*—Rev. Harvey Ashworth; Stephen Woulfe Flanagan, Esq.; Henry Geoghegan, Jun., Esq.; George W. Hemans, Esq., C. E.; John Kennedy, Esq. (formerly an Associate); Henry Kingsmill, Jun., Esq.; John Stratford Kirwan, Esq.; John Locke, Esq.; George MacCartney, Esq.; Richard William Townsend, Esq., C. E.; and Robert Mackay Wilson, Esq.

The following *five* Associates have also joined during the same period, viz.: — John Grainger, Esq.; Joshua H. Lamprey, Esq.; Charles Newell, Esq.; Robert C. Smith, Esq.; and Edward Percy Wright, Esq.

The Society has lost during the year, from death and other causes, *ten* Members, viz.:—George A. Grierson, Esq.; John Hamilton, Esq.; Thomas Hamilton, Esq.; Edward Grattan Holt, Esq.; Thomas Maxwell Hutton, Esq.; Alexander Jack, Esq.; Samuel Jones, Esq.; Frederick M'Coy, Esq.; John Wallace, Esq.; and William T. Wilkinson, Esq.

Also *six* Associates, viz.:—Charles P. Cotton, Esq.; Arthur A. Jacob, Esq.; Alexander Mac Donnell, Esq.; John W. Mallet, Esq.; Joseph O'Kelly, Esq.; and William Thornhill, Esq.

The present state of the Society as to numbers is as follows:—4 Honorary Members, 43 Life Members, 85 Annual Members, and 14 Associate Members; total amounting to 146; being a gain on the year of *eight* Members.

This increase of Members has been accompanied by an increased interest felt by all in the progress of the Society, to meet which your Council have not hesitated to incur additional expense in illustrating your Journal; and they are happy to report that their exertions in this respect, accompanied, as they have been, by a reduction in the price of the old numbers of the Journal, have had the effect of rendering our publications better known among those interested elsewhere in our science.

In order to meet the increased desire of the Members for a speedy publication of our Proceedings, the Council have resolved on publishing the Journal, in future, twice each year; and they entertain the hope that the future numbers of your Journal will increase the reputation of this Society as an active centre of Geological Science. We cannot hope to compete with our elder sister, the Geological Society of London; but, in our own sphere, we may render essential service, by carefully recording the facts we have occasion to observe; at the same time it must be remembered, that in order to do so effectively by our publications, we must provide the means of publishing, which can be best accomplished by each Member persuading some of his friends to join, and unite with us in developing the mineral structure and resources of this country. Your Council are persuaded that the material basis of this country's prosperity depends upon the development of her agricultural and mineral resources. In this development the Geological Society of Dublin can take an active part; and it is a duty which we owe to ourselves to endeavour to increase the knowledge we possess, and to diffuse it. Our sphere may be humble, our place secondary, but let it be said of us that we have done what we could.

During the past summer the Third and concluding Part of Vol. V. of the Journal has been published, and with it a List of all Papers read before the Society since its foundation in 1831. The First Part of Vol. VI. will, it is hoped, be ready for delivery to the Members before the meeting in April.

The following List contains an account of the Donations made to the Society during the year.

DONATIONS

RECEIVED SINCE LAST ANNIVERSARY.

1853.

Feb. 16.—Memoir of the Right Hon. Sir John Sinclair, Bart. Presented by the Publishers, the Messrs. Chambers, Edinburgh.

Feb. 16.—Museum of Practical Geology and Geological Survey:—Records of the School of Mines and of Science applied to the Arts, Vol. I., Part 2. Presented by J. Beete Jukes, Esq.

Feb. 16.—The Isthmus of Darien in 1852.—Journal of the Expedition of Inquiry for the Junction of the Atlantic and Pacific Oceans, by Lionel Gisborne. Presented by H. C. Forde, Esq.

March 2.—Quarterly Journal of the Geological Society of London, No. 33. Presented by the Society.

March 2.—Museum of Practical Geology and Geological Survey:—Records of the School of Mines and of Science applied to the Arts, Vol. I., Part 1. Presented by J. Beete Jukes, Esq.

March 2.—Museum of Practical Geology.—Government School of Mines and of Science applied to the Arts:—Industrial Instruction on the Continent, by Lyon Playfair, C. B., F. R. S. Presented by J. Beete Jukes, Esq.

May 4.—House of Representatives.—William T. G. Morton, M.D. —Sulphuric Ether.—Report of the Select Committee on Dr. Morton's Memorial. Presented by the House of Representatives.

May 4.—Memoirs of the Geological Survey of the United Kingdom.—Figures and Descriptions illustrative of British Organic Remains. Decades IV. and VI.

1853.

May 4.—Museum of Practical Geology and Geological Survey:— Records of the School of Mines and of Science applied to the Arts, Vol. I., Parts 1 and 2. Museum of Practical Geology: Industrial Instruction on the Continent, by Lyon Playfair, C. B., F. R. S. Geological Survey of Great Britain, Sheets 17, 18, 60, 61; 72, N. E., S. W., S. E.; 74, N. W., S. W., S. E.; 75, 76, 77, N. E.; 78, N. W., N. E., S. W.; 79–82. Horizontal Sections, Sheets 18, 19, 20, 21, 23, 24, 26, 27, 28, 29, 30, 35, and 36. Vertical Sections, Sheets 16, 17, 18. The whole presented by the Geological Survey of the United Kingdom, through Sir Henry T. De la Beche, C. B.

May 4.—The Geological Observer, by Sir Henry T. De la Beche, C. B., &c. Second Edition, revised: 1853. Presented by the Author.

May 4.—1793 and 1853, in Three Letters, by Richard Cobden, Esq., M. P. Fourth Edition. Presented by the Peace Conference Committee.

May 11.—Transactions of the Royal Scottish Society of Arts, Vol. IV., Part 2. Presented by the Society.

June 8.—Quarterly Journal of the Geological Society of London, No. 34. Presented by the Society.

June 8.—Popular Physical Geology, by J. Beete Jukes, F. G. S. Presented by the Author.

July 8.—Transactions of the Kilkenny Archæological Society, for the year 1851. Presented by the Society.

Aug. 24.—Report of a Geological Survey of Wisconsin, Iowa, and Minnesota; and incidentally of a portion of Nebraska Territory: made under Instructions from the United States Treasury Department, by David Dale Owen; with a Volume of Illustrations. Smithsonian Contributions to Knowledge:—On Mosasaurus, and the allied Genera, by Dr. R. W. Gibbes. The Law of Deposit of the Flood Tide, by Charles Henry Davis, A. M., &c. Observations on Terrestrial Magnetism, by John Locke, M. D., &c. Memoir on the Extinct Species of American Ox, by Joseph Leidy, M. D. A

1853.

Flora and Fauna within Living Animals, by Joseph Leidy, M. D. Explanations and Sailing Directions to accompany the Wind and Current Charts, approved by Commodore Charles Morris, by Lieut. M. F. Maury, U. S. N. Fourth Edition. Report on the Geology of the Lake Superior Land District, by J. W. Foster and J. D. Whitney—Part 2, The Iron Region, together with the general Geology; with a Volume of Maps. Sixth Annual Report of the Board of Regents of the Smithsonian Institution, for the year 1851. On the Causes of Tornados, by Dr. Hare. Second Edition (three copies). Norton's Literary Register and Book Buyer's Almanack, for 1853 (two copies). The whole presented by the Smithsonian Institution.

Aug. 24.—Boston Journal of Natural History, Vol. VI, Nos. 1 and 2. Proceedings of the Boston Society of Natural History, Nos. 1 to 14. Presented by the Society.

Nov. 9.—Rough Notes of a Trip to Re-union, the Mauritius and Ceylon, by Frederic J. Mouat, M. D. Presented by the Author.

Nov. 9.—Athenæum.—Rules and Regulations, and List of Members, 1852; with Donations to the Library. Annual Report; General Abstract of the Accounts, &c., from 1st January to 31st December, 1853. Presented by the Club.

Dec. 13.—Quarterly Journal of the Geological Society of London, No. 36. Presented by the Society.

Dec. 13.—The Queen's University in Ireland:—Report on the Condition and Progress of the Queen's University in Ireland, for the year ending June 19, 1852, and to September 1, 1853; A. B. and A. M. Degree and Honor Examination Papers, 1853 (two parts); Agriculture Diploma and Honor Examination Papers, 1853; List of the Senate, Professors, and Examiners; and Ordinances regarding the several Courses of Study. Presented by the Secretary, Robert Ball, LL. D.

1853.

Dec. 13.—The Medical Circular, No. 46, New Series. Presented by the Editor.

1854.

Jan. 11.—Proceedings of the Royal Irish Academy, Vol. V., Parts 2 and 3. Presented by the Academy.

Jan. 17.—Arrangement of the British Marbles, Alabasters, Serpentines, Porphyries, Granites, Building Stones, &c., in the Vestibule and Hall of the Museum of Practical Geology, 1853. Museum of Practical Geology and Geological Survey:—Records of the School of Mines and of Science applied to the Arts, Vol. I., Parts 3 and 4. Presented by the Geological Survey of the United Kingdom, through Sir Henry T. De la Beche, C. B.

Feb. 8.—The Athenæum, 1853. Presented by the Editor.

Feb. 8.—The Literary Gazette, 1853. Presented by the Editor.

Feb. 8.—Journal of the Society of Arts, Nos. 12 to 63. Presented by the Society.

Feb. 8.—The Musical Times, Nos. 106 to 117. Presented by the Editor.

Feb. 8.—A Monograph of the Crag Mollusca, or, Descriptions of Shells from the Middle and Upper Tertiaries of the East of England; by Searles V. Wood, F. G. S., Part 1, Univalves (two copies). Monograph on the Fossil Reptilia of the London Clay, Part 1, Chelonia, by Professor Owen, F. R. S., &c., and Professor Bell, Sec. R. S., &c. 4to. London: Printed for the Palæontographical Society, 1848–49. Presented by William Edington, Esq.

Feb. 8.—Quarterly Journal of the Geological Society of London, No. 35. Presented by the Society.

Feb. 8.—Address at the Anniversary Meeting of the Royal Geographical Society, 23rd May, 1853, by Sir R. I. Murchison, G. C. St. S., &c. Presented by the Author.

Feb. 8.—Thirty-third Report of the Council of the Leeds Philosophical and Literary Society, at the close of the Session, 1852-53. Presented by the Society.

1854.

Feb. 8.—Memoirs of the Geological Survey of the United Kingdom—Figures and Descriptions illustrative of British Organic Remains, Decade VII. Museum of Practical Geology and Geological Survey—Records of the School of Mines and of Science applied to the Arts, Vol. I., Parts 3 and 4. Board of Trade—Department of Science and Art—Prospectus of the Metropolitan School of Science applied to Mining and the Arts, 3rd Session, 1853-54 (two copies). On the Educational Uses of Museums, by Edward Forbes, F. R. S., &c. The whole presented by the Geological Survey, through J. B. Jukes, Esq.

Feb. 8.—Reports of the Proceedings of the Geological and Polytechnic Society of the West Riding of Yorkshire, 1852. Presented by the Society.

LIFE SUBSCRIPTIONS.

	£	s.	d.
Lord Talbot de Malahide,	10	0	0
Rev. Professor Haughton,	10	0	0
Richard Purdy Allen, Esq.,	10	0	0
Robert Harkness, Esq.,	10	0	0
Edward Barnes, Esq.,	5	0	0
William B. Webster, Esq.,	5	0	0
Andrew Wyley, Esq,	5	0	0
	£55	0	0

ADMISSION FEES.

Samuel Gordon, M. D.,	1	0	0
Robert W. Smith, M. D.,	1	0	0
John S. Kirwan, Esq.,	1	0	0
Professor England,	1	0	0
William Scott, Esq.,	1	0	0
Stephen W. Flanagan, Esq.,	1	0	0
Richard Wolseley, Esq.,	1	0	0
William Clarke, Esq.,	1	0	0
Rev. H. Ashworth,	1	0	0
	£9	0	0

SUBSCRIPTIONS.

	£	s.	d.
Edward Wright, Esq.,	1	0	0
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Robert W. Smith, M. D.,	1	0	0
Thomas Maguire, Esq.,	1	0	0
James Duncan, M. D.,	1	0	0
A. Jack, Esq.,	1	0	0
Robert Callwell, Esq.,	1	0	0
Dr. Harvey,	1	0	0
Rev. Charles Graves,	1	0	0
A. M'G. Giles, Esq.,	1	0	0
George Yeates, Esq.,	1	0	0
George M'Dowell, Esq.,	1	0	0
Charles P. Croker, M.D.,	1	0	0
Joseph Welland, Esq.,	1	0	0
Earl Fitzwilliam,	2	0	0
Carried forward,	£17	0	0

	£	s.	d.
Brought forward,	17	0	0
John S. Kirwan, Esq.,	1	0	0
H. Medlicott, Esq.,	1	0	0
John J. S. Moore, Esq.,	1	0	0
Gilbert Sanders, Esq.,	1	0	0
John Purser, Esq.,	1	0	0
Thomas Hutton, Esq.,	1	0	0
John M'Donnell, M.D.,	1	0	0
John Patten, Esq.,	1	0	0
Pat. Fenlon, Esq. (1852–53),	2	0	0
Samuel Downing, Esq.,	1	0	0
Robert Ball, Esq.,	1	0	0
R. Hitchcock, Esq.,	1	0	0
Evelyn Shirley, Esq.,	1	0	0
Professor England,	1	0	0
Frederick M'Coy, Esq.,	2	0	0
Carried forward,	£34	0	0

	£	s.	d.
Brought forward,	84	0	0
George Kinahan, Esq.,	1	0	0
Wm. Thomas Wilkinson, Esq.,	1	0	0
Henry H. Head, M. D.,	1	0	0
James Apjohn, M. D.,	1	0	0
Richard Wolseley, Esq.,	1	0	0
William Clarke, Esq.,	1	0	0
The Lord Chancellor (1852–53)	2	0	0
The Rev. the Provost,	1	0	0
William Scott, Esq.,	1	0	0
Robert Harrison, M. D.,	1	0	0
Stephen W. Flanagan, Esq.,	1	0	0
William Edington, Esq.,	1	0	0
Rev. J. Galbraith,	1	0	0
The Lord Talbot,	1	0	0
Rev. J. H. Jellett,	1	0	0
Earl of Bective,	1	0	0
Alexander M'Mullen, Esq.,	1	0	0
M. M. O'Grady, M. D.,	1	0	0
Charles W. Hamilton, Esq.,	1	0	0
Frederick J. Sidney, Esq.,	1	0	0
John Radcliffe, Esq.,	1	0	0
The Lord Chief Baron,	1	0	0
Patrick Byrne, Esq.,	1	0	0
H. W. Allen, Esq.,	1	0	0
Rev. C. W. Wall,	1	0	0
Rev. W. A. Willock,	1	0	0
Rev. A. B. Rowan,	1	0	0
Dr. Allman,	1	0	0
M. D'Arcy, Esq.,	1	0	0
Archbishop of Dublin,	1	0	0
Earl of Leitrim,	1	0	0
John Petherick, Esq.,	1	0	0
Thomas Hamilton, Esq.,	1	0	0
W. H. Curran, Esq.,	1	0	0
Carried forward,	£69	0	0

	£	s.	d.
Brought forward,	69	0	0
J. B. Doyle, Esq.,	1	0	0
Rev. H. Lloyd,	1	0	0
B. D. Gibbons, Esq. (1852–53),	2	0	0
R. M. Wilson, Esq.,	2	0	0
Rev. H. Ashworth,	1	0	0
Richard Griffith, Esq.,	1	0	0
H. Bruce, Esq.,	1	0	0
Dr. Mollan,	1	0	0
Francis Codd, Esq.,	1	0	0
William Dawson, Esq.,	1	0	0
Dr. Whitty,	1	0	0

Associate Members.

	£	s.	d.
Thomas M'Comas, Esq.,	0	5	0
Joseph Kincaid, Esq.,	0	5	0
A. A. Jacob, Esq.,	0	5	0
John Kennedy, Esq. (Composition),	0	10	0
Arthur Jacob, Jun., Esq.,	0	5	0
John Haughton, Esq.,	0	5	0
John Mallet, Esq.,	0	5	0
Jones Pigot, Esq.,	0	5	0
J. K. Reid, Esq.,	0	5	0
E. P. Wright, Esq.,	0	5	0
G. H. Kinahan, Esq. (Composition),	0	15	0
Thaddeus O'Mahony, Esq.,	0	5	0
Joseph Kincaid, Esq.,	0	5	0
R. C. Smith, Esq. (1854),	0	5	0
John S. Maguire, Esq. (1854),	0	5	0
	£86	10	0

ABSTRACT OF THE TREASURER'S ACCOUNT FOR THE YEAR ENDING FEBRUARY, 1854.

Dr.

1853.		£ s. d.
To Balance of last Year's Account,		2 11 5½
— Received for Iron Frames purchased by Mr. Downing,	£0 4 0	
Ditto, by Mr. Haughton,	0 6 0	
		0 10 0
— Received		8 11 6
— "	£55 0 0	
— " Admission Fees,	9 0 0	
— " Annual Subscriptions,	86 10 0	
		150 10 0
— Balance due to the Treasurer,		31 9 5½
		£188 12 5

Cr.

1853.			£ s. d.
Mar. 16.—By paid Assistant Secretary's salary to 14th February,		£10 0 0	
— Servant's wages,		1 10 0	
(per Draft 8820)			11 10 0
— Paid Mr. Waller's account for Engraving (per Draft 8821),			18 0 0
May 4.—By paid for Furniture,		£10 0 0	
— " Sundries, per Assistant Secretary's book,		7 16 2	
(per Draft 8822)			17 16 2
June 15.—By paid Mr. Oldham, in part of his account for			10 0 0
Nov. 2.—By y to		£10 0 0	
—		12 12 8	
			22 12 8
" 16.—By his account for			3 0 0
1854.			
Jan. 18.—By		£38 18 7	
By do. do.		6 18 3	
— Paid for Stationery,		1 2 4	
(per Draft 5128)			46 14 2
Feb. 1.—By paid for two Portfolios (part of Draft 5129),			1 5 0
By 3¼ per Cent Stock, purchased with Life Subscriptions, viz.:			
1853.			
June 1.—Per Draft 8823,	Stock £19 7 4	£20 0 0	
Nov. 2.— " 8825,	" 9 16 0	10 0 0	
Dec. 21.— " 5127,	" 10 4 9	10 0 0	
1854.			
Feb. 1.— " 5129,	" 15 19 5	15 0 0	
			55 0 0
By Collector's Poundage,			7 10 6
— Postage,			0 3 11
			£188 12 5

WILLIAM EDINGTON, *Treasurer.*

The following Officers for the ensuing year were then declared duly elected, and the Society adjourned to receive the President's Annual Address:—

President:

JOSEPH BEETE JUKES, M.A., F.R.S., M.R.I.A.

Vice-Presidents:

HUMPHREY LLOYD, D.D., S.F.T.C.D., M.R.I.A.
ROBERT BALL, LL.D., M.R.I.A.
LIEUT.-COL. PORTLOCK, R.E., F.R.S., M.R.I.A.
ROBERT MALLET, C.E., M.R.I.A.
JAMES APJOHN, M.D., F.R.S., M.R.I.A.

Treasurers:

WILLIAM EDINGTON, ESQ., M.R.I.A.
SAMUEL DOWNING, C.E.

Secretaries:

REV. PROFESSOR HAUGHTON, F.T.C.D., M.R.I.A.
FREDERICK J. SIDNEY, LL.D., M.R.I.A.

Council:

RICHARD GRIFFITH, LL.D., F.R.S., M.R.I.A.
C. W. HAMILTON, ESQ., M.R.I.A.
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PROFESSOR ALLMAN, M.D., M.R.I.A.
GEORGE M'DOWELL, F.T.C.D.
REV. PROFESSOR JELLETT, F.T.C.D., M.R.I.A.
EDWARD WRIGHT, LL.D.
GILBERT SANDERS, ESQ., M.R.I.A.

ANNUAL ADDRESS

DELIVERED BEFORE THE

GEOLOGICAL SOCIETY OF DUBLIN,

FEBRUARY 8, 1854,

BY

JOSEPH BEETE JUKES, M.A., F.R.S.

PRESIDENT OF THE SOCIETY.

YOU will doubtless recollect, Gentlemen, that when our late President, Dr. Ball, prematurely resigned the office last year, induced thereto, to our great regret, by ill health and pressure of other business, he said that he left it as a debt due by the Chair to review the sixteen papers which were laid before you during the year of his presidency, and trusted to me to clear it off on the present occasion.

I should at all times, Gentlemen, be most anxious to comply with any wish of my friend Dr. Ball, and will therefore endeavour to meet the spirit, if not the precise words, of his request, by taking as the subject of the present Address not merely our own progress but the general progress of Geology during the past two years. As, however, this is too large a subject to be compressed into so short a space with any hope of justice being done to it, and as time and means would alike fail me in making this review a general one for the whole world, you must allow me to confine myself chiefly to our own islands, and even then to select from the publications of the last two years such as appear to me to be of the most general interest. Among these I shall hold as the chief the publications of our great prototype, the Geological Society of London. I will endeavour then, in addition to a notice of our own works, to give you a brief account of what they have been doing, and of one or two other contributions to our general knowledge; and I think perhaps I

may thus more usefully occupy your time than if I confined myself to reciting and criticising that with which you ought to be already sufficiently familiar,—namely, the papers which have been read at our own meetings.

In reviewing the publications of the Geological Society of London I shall include the two Presidential Addresses for 1852–53, because they contain very valuable contributions to our stock of general information on two subjects of great interest and importance. When I remind you that their author is the eminent Cambridge mathematician and physicist, Mr. W. Hopkins, you will at once be aware of the value of these contributions.

GEOLOGICAL PHYSICS.

In his Address of last year Mr. Hopkins has done a great service to all those of us who have not the time to read large and profound books, and who do not possess much mastery of the language and processes of mathematics, by giving us a popular account of the great work of M. Elie de Beaumont on "The Systems of Mountain Chains." Mr. Hopkins speaks in the highest terms of the great ingenuity, the perfect acquaintance with the mathematics of the subject, the care and labour bestowed on elaborating all the details, the unflinching honesty which leaves no part of the subject without complete investigation, and the candour of statement displayed by the eminent author of this great work.

In endeavouring to condense Mr. Hopkins's account of it, and to reduce his description into still more familiar terms, I fear I must be led into some inexactness or incompleteness of statement; but all I aim at is to give you such a clue to the general bearings of the subject as may induce you to give and facilitate your giving a careful and patient perusal to Mr. Hopkins's Address, and thus enable you to make yourselves more complete masters of the theory of M. Elie de Beaumont.

You are aware that the main point of this theory is to prove that those mountain chains that run parallel to each other have been elevated at the same time, or rather, perhaps, that all mountain chains of contemporaneous elevation run parallel to each other. Now, in the first place, what do we mean, when we speak of the globe generally, by mountain ranges being *parallel* to each other? It is obvious that when we take comparatively small portions of the earth's

surface, such as England and France, or France and Spain, that the compass-bearing will give us a sufficiently accurate measure of parallelism. A mountain chain running N. E. and S. W. in England will be parallel to a N. E. and S. W. chain in France, with quite sufficient accuracy for our purpose. If, however, we take a terrestrial globe, and draw on different portions of it widely apart from each other lines representing mountain chains, each running N. E. and S. W. (of course I mean corrected for the variation of the compass), you will see that these different lines are by no means *parallel* to each other in any sense in which that term could possibly be applied.

Suppose we draw such a line, say a thousand miles long, passing through London, and another through the antipodes of London, and the globe were transparent, and we were to hold it up to the light in such a position as to make those two points coincide, we should see that the N. E. and S. W. lines, instead of being parallel, crossed each other at right angles. In the same way, in a terrestrial globe, all the meridians have the same compass-bearing—namely, due N. and S.; but instead of being parallel, they all converge at the poles, where they cross each other at all kinds of angles. That lines having the same compass-bearing are not parallel to each other may be shown also in this way:—Suppose the globe to be all covered with water, and the variation of the compass not to exist, and a vessel in the Antarctic regions were to start on an E. N. E. course, it is clear she would sail round and round the globe, continually getting farther north until she found herself in the Arctic regions, having thus described a great spiral round the globe of several turns; but no part of a spiral can be considered as *parallel* to any other part.

Again—the meridian lines on a globe are all great circles; that is, if we suppose the earth to be cut through by a plane coinciding with any meridian line, that cut would pass through the centre of the earth, and the globe would be divided by it into two equal parts, or two hemispheres: and when we consider the matter, we shall see that no two planes, each of which coincides with a great circle, can be parallel to each other. If we cut an orange into two halves, and then divide it again into slices by cuts parallel to the first, these slices will be smaller and smaller as they recede from the first, and none of them can by possibility pass through the centre

of the orange except the first: in other words, all the parallel planes cutting through the orange except the first must form small circles, and only one can produce a great circle.

Again—if we travel round the globe, keeping on the circumference of a great circle, we shall, on all such circles except the equator, be continually altering our compass-bearing. Suppose we travel along the circle called the Ecliptic. If we started on the equator, at the point called the vernal equinox, and proceeded in to the northern hemisphere, we should set out on a course running nearly E. N. E.; but when we had proceeded nearly a quarter round the globe, and were approaching the tropic of Cancer, we should have gradually fallen off from that course into one nearly due E., and for a short space, as we actually touched upon the tropic, our course would be really east. We should then commence returning towards the equator, and as we crossed it at the autumnal equinox our course would be E. S. E.; again getting more easterly as we advanced into the southern hemisphere, becoming due east at the tropic of Capricorn, and returning to the point we started from in an east-north-east direction, as before. Still, although our compass-bearing thus altered, we may see that every portion of the circumference of this great circle called the ecliptic must be considered parallel to every other portion when we look at it as the edge of a great plane cutting through the centre of the earth. We see, then, that lines having the same compass-bearing (unless they are east and west lines, or parallel to the equator), are not at all parallel to each other if they are removed by any considerable portion of the earth's surface; and that lines which are strictly parallel to each other, when we look at the earth *ab extra*, as it were, do not always preserve the same compass-bearing.

Now M. Elie de Beaumont's definition of what he means by parallel chains is, that those chains are parallel to each other which can be shown to be parts of small circles which are parallel to the same great circle. If, for instance, there were a number of mountain chains in different portions of the earth running in such directions that the lines representing them on a terrestrial globe could, if continued, be made to form parts of different small circles, all parallel to the great circle of the ecliptic, those mountain chains would be considered by M. de Beaumont as parallel to each other, and forming one system of mountains.

Recurring to the orange for the sake of illustration, if we cut it in any direction clean through the middle, and then slice it by a number of cuts parallel to the first, the lines described by these cuts on the surface of the orange would represent a system of parallel mountain chains, according to M. de Beaumont,—the first cut being the great circle to which all the rest are referred.

In order then to decide whether any two or more mountain ranges are parallel to each other, he first ascertains whether lines drawn through their middle point, at right angles to their general course, will cut the same great circle at right angles, or, in other words, whether they can be considered as forming parts of small circles parallel to the same great circle. This great circle he calls the great circle of comparison, or great circle of reference of each system. This explanation, I believe, is sufficiently exact to enable us to understand what M. E. de Beaumont means by *parallel systems of mountain chains.* He asserts that all the mountains of each system were contemporaneously elevated,—meaning, I believe, to take the term contemporaneous in its strict sense, as referring to the same instant of time. Mr. Hopkins justly remarks that this strictness "is not essential to M. de Beaumont's mechanical views on the subject, and his theory of parallelism may be as applicable to the result of a *succession* of movements during a *comparatively* short, definite period as to the effects of a single movement. Some of the movements might reasonably be supposed to have been sufficiently energetic to stamp at once their impress on the geological character of each district; but I see no adequate reason why the theory should altogether reject the idea of subordinate movements in the same system."

Having described M. de Beaumont's idea of parallelism, Mr. Hopkins also examines the descriptive part of his work, where he applies it to the observed directions of different ranges of mountains. Of these M. de Beaumont reckons twenty-one systems, principally founded on observations made in Europe, though supposed to be applicable to mountains in other parts of the globe. Of this part of M. de Beaumont's work Mr. Hopkins justly observes, that it is necessary very carefully to discriminate between those systems of mountain ranges, the elevation of which is proved to have been contemporaneous by *geological evidence independent of the theory*, and

those whose contemporaneity is held to be proved in consequence of their parallelism.

It is obvious that for the theory to rest upon any secure basis of observed fact, it is necessary for the number of cases where the contemporaneity of parallel systems of mountains is proved by independent geological evidence to be very large in proportion to the number where they are only assumed to be contemporaneous because they are parallel.

Mr. Hopkins discusses the evidence adduced in support of each of the twenty-one systems mentioned by M. de Beaumont. In many of these the geological time of their elevation, even where that rests on evidence independent of the theory, is still indeterminate by reason of the want of the complete and accurate determination of the exact age of some of the rocks affected; in others, it is probable that the line of elevation is rather a local deviation, resulting, perhaps, from disturbances of a subsequent period than a normal direction of a mountain chain. In others, again, a distinct epoch of elevation is assigned to periods, such as one between the mountain limestone and the millstone grit, or between the millstone grit and the coal-measures,—divisions which have only a local and partial existence, and between the formation of which I know of no evidence from any independent geological characters proving any interval or any discontinuity to have occurred. Others again of M. de Beaumont's lines are curved lines, which he accounts for by supposing a mixture of systems, or one movement modified by another; and again he splits up some districts, showing *parallel curved* lines of elevation, to assign them to different systems, widely apart geographically, and with which there is no other evidence of connexion than this parallelism. Unless I were to literally copy a large portion of Mr. Hopkins's Address, it would be impossible for me to do justice to this portion of the subject; I must therefore refer you to that Address itself.

There is a second portion of M. de Beaumont's theory quite independent of the first, of which I will try to give you a very brief description:—Assuming the first part to be true, namely, that there are many systems of contemporaneous parallel mountain chains, all those of each system being parallel to one great circle of reference, he endeavours to discover, whether these great circles of reference have

not some symmetrical relation one to the other; and if so, what that relation is.

In this part of his theory M. de Beaumont seems to deal still more largely in assumptions than in the former part. He appears, with much labour, to have calculated and tabulated the angles at which *the directions* of his great circles of reference cross each other, and to have been struck with an occasional appearance of symmetrical relation between one group of them seeming to approximate in direction, and another group which seemed to have a tendency to cross the former perpendicularly; so that there were alternations of groups and gaps between the lines. It appeared also that there was an occasional recurrence of the same angle, as for instance that of nearly 22°, between the directions of several pairs of great circles of reference. In endeavouring to discover what the relation was, however, it appears to me clearly that M. de Beaumont has *selected* such a geometrical system as gave the greatest number of relations of symmetry with which to compare the supposed relations of his great circles of reference; so that the probability of the latter coinciding with some of the former became very high. M. de Beaumont adopts a geometrical system of lines, founded on the pentagon, and calls it a "reseau pentagonal," or pentagonal network.* It is possible to draw fifteen great circles on the globe at such angles, and in such positions, that they shall divide its whole surface into twelve equal pentagonal spaces, so arranged that two of these pentagons shall be exactly opposite to each other, and shall be each surrounded by five others, which shall have each one side in common with one of the others. M. de Beaumont then proceeds to bisect each of the sides of these pentagons, and joining the nearest points of intersection by lines, which can be extended into other great circles, he forms other regular pentagons inside the first set; and again, by joining the alternate points of intersection by lines which are likewise to be extended into great circles, he forms another still interior set of pentagons; and again, by joining other points of intersection which arise during this pro-

* This portion of M. E. de Beaumont's theory has already been described to you by my able predecessor, Colonel Portlock, in his first Address. I have, however, thought it better not to omit Mr. Hopkins's views of it, both because he differs from Colonel Portlock in his estimate of its real value, and in order to lay before you a connected account of the whole of M. de Beaumont's theory.

cess, he gets many other sets of great circles, all having a certain symmetrical relation to the first set, until the whole sphere can be covered by a network of ever increasing complexity. It is true that M. de Beaumont assigns certain numerical values to these different sets of great circles, reckoning the more simple and earlier ones at much higher rates than those of later result: still, even these values are assigned arbitrarily.

He then tries graphically on a globe, with such a pentagonal network made of fine thread, whether it was possible to find any point, in Europe for instance, where, by making it the centre of his pentagon, he could turn that network about till some of the principal lines of it should coincide with the directions of some of his observed systems of mountain chains. He finds such a point near Remda, in Saxony; and by making that the centre of his pentagon, and making one of the lines of his network coincide with one of the lines of the mountain systems, he finds that the lines representing the direction of the great circles of reference of ten other systems pass through this point.

Mr. Hopkins, however, shows that it necessarily follows from one of M. de Beaumont's assumptions that many of the great circles of reference should meet, or nearly meet, somewhere in Central Europe, and that the complicated nature of the pentagonal network is such that the same result of *approximate agreement* would necessarily be found for any sets of circles drawn completely at random. He therefore, though with much reluctance, decides in his own mind against the establishment of the "reseau pentagonal," while giving, at the same time, high praise to the author for his ingenuity, for his industry, and for the profound knowledge displayed by him in his work.

The physical cause involved in M. de Beaumont's theory is, that the phenomena of elevation are the result of the shrinking of the earth's crust, arising from the refrigeration of the interior, supposed to be, or to have once been, in a state of fusion.

While agreeing to a certain extent in the probability of the cause, Mr. Hopkins remarks, that he would have great difficulty in tracing to it the sudden and violent actions contended for by M. de Beaumont, and would rather expect from it a gradual action, with occasional slight and frequently recurring paroxysmal starts, in accordance with the gradual nature of the process of refrigeration.

Finally, Mr. Hopkins sums up by saying that M. De Beaumont's theory cannot be accepted, as proved by *a priori* reasoning, but must be judged hereafter by its accordance with observed fact,—remarking, "that the phenomena of elevation, within certain districts, are usually connected by some geometrical law; and that such law is frequently that of parallelism I conceive to be beyond all doubt; and moreover, I think it almost equally beyond reasonable doubt that the phenomena thus connected may be considered as contemporaneous, not necessarily, in M. De Beaumont's absolute sense of the term, but at least as regards the principal of those movements to which the phenomena are referable. That the law of parallelism, however, especially as restricted to *straight* lines alone, is the only law which may characterize a system of lines of elevation, I cannot admit. The law of *divergency* may in some cases be distinctly recognised, as in the lake district of the north of England."

In short, gentlemen, it appears to me that our knowledge may be roughly summed up as follows:—Forces of elevation seem in some instances to have acted on points, producing dome-shaped elevations and diverging cracks; sometimes on lines, producing linear elevations and cracks; sometimes on spaces having both length and breadth, when parallel elevations and depressions have been produced, running in the direction of the *length* of the district, and having cracks both longitudinal and transverse. It appears probable, moreover, that the linear and the dome-shaped elevation have sometimes been combined so as to have modified each other, and it is obvious that the ends of a linear elevation must always have more or less of a semi-dome-shaped or apse-like structure. Lastly, it appears to me that M. De Beaumont's theory is too complete and too neat and precise, as well as too complex, if not for nature itself, at all events for the present state of our knowledge of nature; and that, though far too important a theory to be lost sight of, it must still remain a problem to be solved by observation rather than be received into our science as a guiding rule to aid us in observing.

The next subject of which I shall endeavour to give you a brief account is one treated of by Mr. Hopkins in a paper, and in his published Address in the early part of 1852. The paper is "On the Causes which may have produced Changes in the Earth's superficial Temperature;" and the principal subject of the Address is on "The

Drift," the origin of which the paper is chiefly intended to explain. Mr. Hopkins divides his paper into two parts: the first is "*on the influence of the earth's internal heat, and of the heat radiating from external bodies on the earth's superficial temperature.*" He establishes the following data to commence with:—

1. The mean annual temperature of the surface of the earth equals that of the air close to it.

2. The mean annual temperature below the surface is the same down to the depth of 60 or 70 feet, the oscillations felt at the surface becoming less and less as we descend, until at about that depth the mean temperature would be constant.

3. At depths greater than 60 or 70 feet the temperature is constant, and increases directly as the depth.

4. The temperature of any part of the earth's surface now is due partly to the remains of the earth's primitive heat (supposing that internal temperature to have existed) and partly to the heat received from the sun during the whole term of the earth's refrigeration. Now Poisson has shown that the remaining effect of the earth's internal heat, at the surface, is certainly not greater than $\frac{1}{10}$° Fahrenheit, and that the refrigeration must have been so slow that an enormous series of millions of years has elapsed since the internal heat exerted an effect of 1° on the surface; moreover, as the increase of temperature now is equal to 1° of Fahrenheit for every 60 feet of descent, when the effect of the internal heat amounted to 1° at the surface, the rate of increase must have been 20° for every 60 feet of descent, and when the superficial effect of the internal heat was equal to 10°, we should have, at a depth of 60 feet, a temperature of 200° at least, with an increase of 200° for every sixty feet of descent. All except surface springs then must have been boiling water, and animal life perhaps impossible. It follows from this, as it appears to me, that as we have some of the older rocks, for instance, some Silurian rocks, still unaltered by heat, and in the condition of soft clays and incohærent sandstone, the refrigeration of the earth's surface (supposing it to have been once fused) must already have reached nearly its present limit, at the very early period of the deposition of those Silurian rocks, for we can hardly suppose it possible that there is any Silurian rock which has not, either at the close of the Silurian period or during some paleozoic era, been buried under many hundreds, if not many thousands, of

feet of other accumulations, and therefore if at any of those periods the superficial effect of the internal heat were 1°, and its rate of increase 20° for every 60 feet of depth, such portions must have been brought within reach of a very high temperature, sufficient at least to have affected soft clays and sands full of lime, and other materials likely to act as fluxes.*

5. The fifth conclusion established by Mr. Hopkins is, that any effect arising from internal heat could only be one of gradual refrigeration, and could not produce any oscillations of temperature.

He then discusses the question of the possibility of the temperature of the earth's surface being increased by the near approach of the solar system (in consequence of its own proper motion) to any other body, such as a star; he shows the extreme improbability of this, and also that neither from this source should we get any *oscillation* of temperature, as, although a star might be a centre of heat, we do not know of any centres of cold.

The second part of Mr. Hopkins's paper is "*On the influence of various configurations of land and sea, and oceanic currents on the earth's superficial temperature.*"

In this part, taking as his guide the admirable and useful maps of isothermal lines by Dove, he discusses the cause of the well-known but extraordinary deviation from their normal course of the isothermals in the west of Europe, examining what would be the effect of each of the following hypotheses:—

1. Configuration of land and sea as at present, but no gulf stream.

2. Gulf stream as at present, but a solid barrier of land from Scotland to Ireland and Greenland.

3. All the north Atlantic converted into land, and Europe joined to America.

4. Large parts of North America and Europe submerged, and the gulf stream diverted into some other course.

He inquires what would be the probable positions of the summer andwinter is othermals in each of the above hypothetical cases; describes what is known as to the present level of the snow-line and

* As one locality where this must have occurred, I may instance the part of Shropshire west of Wenlock Edge, where the Wenlock shale and upper part of the Caradoc sandstone must have been covered by all the Ludlow rocks at least, and most probably by the Old red sandstoneand Coal-measures.

the limits of the descent of glaciers, and what their probable levels would be in each of those hypothetical cases; and lastly examines the relative claims that those four hypotheses have on our acceptance.

On the first hypothesis, that of the configuration of land and sea being as it is now, but the gulf stream being absent, we should have the following results:—The January isothermal of 32°, instead of running, as it does now, from Holland to the coast of Norway, would strike from central Europe through the west coast of Brittany; and that of 23° would cross through the middle of England and Ireland, about the latitude of Dublin, instead of running, as it does now, through the gulf of Finland and Lapland to the North Cape, and thence between Iceland and Greenland.

On the summer isothermals, on the contrary, the absence of the gulf stream would have but little effect, since the temperature of the North Atlantic and of Western Europe is naturally raised by the summer sun to a point above that of the gulf stream, which therefore cannot raise it any higher. The July isothermal of 63°·5, for instance, which passes just south of London, would pursue exactly the same course it does now if the gulf stream were taken away, and the others would be nearly parallel to it. On this hypothesis, then, we should have the same summers we have now, but the winters of Lapland or the Labrador, with all our seas frozen over. The farther we go north the greater would be the effect of this abstraction of the gulf stream on the *mean annual* temperature. About the Alps this would not be lowered more than 2°, about Snowdon it would be lower by 7½°, in the north of Scotland by 12½°, and in Iceland by 18°.

On the second hypothesis, the gulf stream remaining, but land connecting Scotland and Greenland, we should have the effect of the gulf stream concentrated in the North Atlantic; the January isothermals would run nearly N. and S. from Iceland to Central France, while Scandinavia, being deprived of the effects of the gulf stream, would have its winter temperature greatly diminished, and its mean annual temperature considerably lowered.

On the third hypothesis, namely, dry land stretching from Europe to America, the isothermal lines would preserve their parallelism as in Central Asia, running in straight lines, or nearly so. In that case, the January isothermal of 32° would run nearly

E. and W., not far from the parallel of 40°, or about the latitude of Constantinople, Naples, Madrid, and Pennsylvania, and the winter isothermals of 23°, 14°, and 5°, which in Central Asia and Central America are nearly parallel to 32°, would be continued parallel throughout their course, that of 5° passing through the S. of England, and altogether S. of Ireland. This would be tantamount to giving us the winter temperature of Tartary and Siberia, Nova Zembla, Spitzbergen, Greenland, and Hudson's Bay. On the summer isothermals the effect of converting the Atlantic into dry land would be to draw them also into straight lines, bringing the northern ones more south, and the southern ones more north. The total effect on the mean annual temperatures of the same places, as before, would be a diminution—

At the Alps, of	11°
At Snowdon, of	20°
At the North of Scotland, of	26°
At Iceland, of	25°

The fourth hypothesis, namely, all the low land of Europe converted into sea, and the gulf stream absent, gives us the case of the glacial sea,—a case especially interesting to geologists, as being the conditions under which we believe the drift to have been formed.

Mr. Hopkins examines the probabilities under this hypothesis in some detail; but it may be sufficient if I say here, that the results arrived at are very much in accordance with those in the first hypothetical case, modified by the effects which a preponderance of sea over land would produce,—namely, the equalization of extremes, the lowering of southern, and the raising of northern temperatures. The isothermal lines would probably run, as before, nearly straight, the January one of 32° cutting the coast of France a little south of where it was placed under the first hypothesis, and the others following, so as to lower the mean annual temperatures of the places mentioned before by 2° or 3° more than by the first hypothesis, principally from the diminution of heat during the summer.

Mr. Hopkins then investigates the question of the height of the snow-line and the descent of glaciers generally, and for each of the above hypotheses. The snow-line is that line where snow is permanent throughout the year: it therefore depends on the *summer* temperature, and not on the mean annual temperature. The snow-line

will therefore be lowest where there is greatest humidity to cause the deposition of snow, and the temperature is most equable, or where the extremes of summer heat vary least from the mean. For this reason the snow-line will not always coincide with the line where the mean temperature is 32° Fahr.

From the result of observations, it appears that we may take a decrease of 1° F. as corresponding to elevations varying from 320 to 500 feet,—the smaller number being that of ascents in balloons, and up the sides of very steep, isolated mountains; the larger, of a succession of swelling table lands and wide-spread mountain ranges. If, therefore, we know the mean temperature of any place at the level of the sea, and the nature of the rising ground, we can calculate the height at which the mean temperature of its highlands would be 32°.

From Humboldt's observations, it appears that at Chimborazo the mean temperature of the snow-line is 34°·7; at St. Gothard it is 25°·3; and under the Polar Circle, 21°·2: in other words, the snow line is 1000 feet lower than the line of 32° at Chimborazo, 2000 feet above it at St. Gothard, and 3500 feet above it under the Polar Circle. In N. E. Asia, from the defect of moisture and the continental or excessive climate (as to summer heat), the height of the snow-line is probably still higher above that of 32°, while in Iceland, from its insular situation, combining humidity with equability of temperature, the snow-line coincides with that of 32°. It is important to recollect that other conditions remaining the same, the conversion of a continent into an archipelago of islands lowers the height of the snow-line.

The vertical descent of glaciers below the snow-line will depend on the thickness of the glacier, the rate of its motion, arising from the steepness or otherwise of its bed, and the activity of the destructive agencies to which it is exposed. Observations on the great glaciers of the Alps give a mean of about 4500 feet for the vertical descent below the snow-line, and with this result some of those of the Himalayah and other mountains in different parts of the world sufficiently coincide.

Starting with these data, Mr. Hopkins shows, that supposing the climate of Western Europe to have been as it is now, and simple elevation of the land to have taken place, it would be necessary, in order that glaciers should descend from the Alps to the Lake of Geneva, and from Snowdon to the low lands between it and the sea,

that those districts should be elevated from 6000 to 8000 feet above their present levels. In higher latitudes the elevation required would be less; but speaking generally, in order that glaciers should descend from the present mountains of Western Europe to the parts that are now near to the sea level, it would be necessary that the whole of that region should be raised into an elevated range from the Polar Circle to the southern margin of the Alps, rising in some parts to a height of 10,000 or 12,000 feet. But such an enormous elevation could hardly take place without leaving great cracks and dislocations in that and the adjoining districts referable to it, while of such dislocations we cannot now find any traces. For this, therefore, and other reasons, its existence seems to be very improbable.

On the hypothesis of the North Atlantic being converted into dry land, although the mean annual temperatures would be lowered very much, yet the extremes of summer heat and winter cold would be greatly increased, and the humidity greatly decreased, which two occurrences, so far as the height of the snow line and production of glaciers are concerned, would counterbalance the lowering of the mean annual temperature. The new continent would be like that of Central Asia, where, although the Altai Mountains are 9000 or 10,000 feet high, and the mean annual temperature is under 32°, yet the glaciers on them, according to M. Tchihatcheff, are of little magnitude or importance.

On this hypothesis, then, in order to get glaciers such as those whose effects have been observed in our mountains, it would still be necessary to elevate them at least 4000 or 5000 feet above their present level.

We now come to the hypothesis which supposes all Western Europe submerged 500 or more feet below its present level, so that the sea should flow all over the low lands, and that the gulf stream should be absent.

In the case of Snowdon we might then have a group of islands, whose tops still reached about 3000 feet above the sea, with a probable mean temperature of 39° or 40°, the height of the line of 32° F. being probably about 2200 feet, or 800 feet below their summit. There would be much humidity and an equable temperature, so that the snow-line might coincide with the line of 32°, and glaciers might descend from it to the level of the sea. If, in addition to these circumstances, we supposed a cold current to set in

from the north, the mean annual temperature might be still further lowered 3° or 4°, principally by lowering the *summer* temperature to the extent of 6° or 8°. This might bring the snow-line down a thousand feet lower, and bring glaciers down to the level of the sea, not only in Snowdon but on the lower mountains of Ireland.

In the Alps, if we suppose a cold northerly current setting down upon their bases, equalizing the climate by lowering the summer temperatures, as the gulf stream does now by raising the winter ones, the mean temperature would be about 45°, and the height of the snow-line would probably coincide with that of 32°, each being about 5000 feet above the sea, and glaciers might descend to the sea level where that penetrated to their bases, and the slope of the mountains was steep enough to admit of a rapid descent of the glaciers. This would suppose the Alps depressed about 2000 or 3000 feet below their present level.

"Thus it would appear from this investigation that the same conditions which would produce glaciers in our Welsh and Irish mountains, descending to the level of the sea from a snow line 1000 to 1500 feet above it, might also produce similar phenomena in the Alps, with a snow-line 5000 or 6000 feet above the sea. In more northerly regions there would, of course, be no difficulty in accounting for the existence of similar glaciers."

Mr. Hopkins then discusses the claims of the before-stated hypotheses on our attention, and gives the preponderance greatly to the latter. As the most probable method of *getting rid* of the gulf stream from the neighbourhood of Western Europe, he supposes that when that was depressed a similar depression took place in North America to the extent of about 2000 feet. The whole plain between the Alleghanies and the Rocky Mountains would then be under water, and the gulf stream, instead of rushing from the Gulf of Mexico through its present narrow outlets by the Bahamas, would run up this central North American sea, carrying a body of warm water in that direction into the Arctic Ocean. This would raise the temperature of the north-western part of America, and the whole north-east of Asia, and would necessarily cause a return current of cold water to flow down to the south, in our portion of the globe. The very same cause, then, which gave to this part of the world the low temperature necessary to produce the phenomena of the glacial sea would give to North-eastern Asia a climate fitted for the support of the herds of mammoths and other huge mammals that for-

merly roamed over the plains of Siberia. This, too, would explain the fact of none of these remains having been found in the plains of North America east of the Rocky Mountains, and would account for the subsequent destruction of all these animals in Asia, on the withdrawal of the gulf stream, consequent on the elevation above the sea of the central plain of North America.

Such is a very brief and necessarily imperfect abstract of Mr. Hopkins's highly important and masterly paper. I will now proceed to examine that portion of his Presidential Address, delivered in 1852, which relates to the kindred subject of—

THE DRIFT.

In discussing the probable cause concerned in the production of those accumulations which we commonly call "Drift," Mr. Hopkins remarks that the moving force of a current estimated by the weight of a block of any assigned form and material, that may be stirred by it, increases as the sixth power of the velocity of the current. In other words, if you double the swiftness of a current, it will move blocks sixty-four times as heavy as before, supposing them to be of the same shape and substance; and if you treble the velocity, it will move blocks 729 times as heavy as before; quadruple it, and its propelling power becomes multiplied by 2048. We are therefore liable to miscalculate the force of a current by reasoning from the ordinary ones that come under our observation.

Mr. Hopkins considers the distinct recognition of the three agencies, glaciers, floating ice, and currents, essential to the establishment of sound theoretical views on this subject. He cautions us, very wisely, not to hold too stoutly to our preconceived opinions on this subject, but to be ready to admit whatever agency may be the *most probable* for any particular case, and not to adhere too strongly to any favourite cause, which may be only a *possible* one.

Mr. Hopkins first examines the striæ and scratches upon rocks. These, he says, when observed in any particular locality, seem to be characterized by the law of parallelism, but when the whole region comes to be examined, they appear to be really divergent. This is the case in Scandinavia, where the striæ radiate from the mountains to the sea, and also in Scotland, where Mr. Hopkins describes them as radiating from several centres. The erratic blocks, whose course Mr. Hopkins next examines, seem to obey a similar law of diver-

gency, following in Scotland along the courses of the principal valleys, as they likewise appear to have done in Scandinavia. We can understand, he remarks, how ice, while travelling down these valleys, should produce locally parallel striæ, radiating from the central mountain mass; but to what cause are we to attribute this prevailing direction being carried out beyond the mouths of the valleys in the open seas? To this question Mr. Hopkins replied by pointing to "waves of translation," caused by sudden and frequent, though not extensive, upward movements of the land.

In North America there appears to be no divergency in the directions of the striæ; but a general parallelism in a N.W. and S.E. direction, the striæ even crossing over the shoulders of mountains in this way, although in the bottoms of the valleys they appear to run parallel to the sides of the valley.

In our own immediate neighbourhood in the county of Wicklow, Mr. Wyley has pointed out to me the vast accumulation of granite boulders at the mouths of some of the principal valleys issuing from the granite hills, and streaming out beyond them over the adjacent country; and any one traversing the county between those hills and the sea must have been struck with the size and frequency of the blocks perched on the tops of the hills, or scattered far and wide over the lower lands.

It is, however, to be remarked, that on their issuing from the valleys, they seem to follow no particular course, and on the west of the hills, towards the county of Kildare, the granite blocks, though not absolutely wanting, are yet much fewer, much smaller, and are confined much more closely to the immediate neighbourhood of the hills, than on their eastern side. These facts would seem to point to icebergs, or to masses of shore ice, acted on by a local current setting to the east, rather than to waves of translation, acting equally in all directions, as the means of transport of these boulders.

Mr. Hopkins next considers the arrangement of materials, and says, that amidst much confusion it appears to come out as a general result that the predominance of finer materials is to be found in the lower part of the drift, and of larger and coarser in the upper. The lower mass frequently consists of fine argillaceous and arenaceous sediment, sometimes mixed with rolled pebbles, the large erratic blocks being superincumbent on this mass, though doubtless sometimes embedded in it. This generalization also coincides with our experience of drift in Ireland.

I may, perhaps, here be allowed to remark, that there is in Ireland a vast field for any geologist who would take up the subject of the drift with a determination to work it thoroughly out. For this object papers giving accurate descriptions of observed facts in particular localities would be of the greatest use; I therefore hailed with great satisfaction the letters we received from Mr. Stanley, giving us some observations on the drift of the neighbourhood of Tullamore.

Although we might not be prepared to accept all the conclusions stated in Mr. Stanley's letters, it must still be a gratification to us to find any earnest and enthusiastic man endeavouring to work out for himself the phenomena of his own district, since we know that any one who thus works patiently and perseveringly, with the single desire of arriving at the truth, will ultimately reach it, and will be rendering the greatest service to our science by the extension of observed and recorded facts.

The letter from the Rev. A. B. Rowan, of Belmont, Tralee, describing a limestone boulder on the side of a hill 600 feet above the present level of the limestone of the neighbourhood, though speaking of a fact sufficiently familiar to us all, gives us a satisfactory indication of the existence of another good observer, who would render us good service if he would only extend and record his observations.

My friend and colleague, Professor Ramsay, published, during 1852, his paper on the "Sequence of Events during the Glacial Epoch, as evinced by the superficial accumulations of North Wales." In this paper the author describes the polishing and striation of the rocks *beneath* the drift accumulation, and also the moraines caused by glaciers subsequent to the deposit of the drift, which glaciers had in one instance scooped a great channel in the drift, clearing it entirely away from one side of a valley. He also showed that the accumulation of blocks and *debris* on the seaward flanks of the Caernarvonshire Mountains were part of a connected deposition of drift, which stretched continuously along them, reaching sometimes to the height of 2000 or 2300 feet above the sea, proving a depression of the land to have once taken place, to at least that amount below its present level. Professor Ramsay attributes these phenomena to, first, a great elevation of the land, causing the first great glaciers, which produced the polishing and striation, then a depression beneath the sea in which the drift was accumulated; and lastly, a

re-elevation producing another glacier period. Mr. Hopkins does not agree with Professor Ramsay in his first great elevation, since he shows, in the paper I have just described to you, that glaciers might have been formed on Snowdon by the abstraction of the gulf stream, and the bringing in of a cold current from the north, but in the subsequent sequence of events there would, I believe, be no great difference of opinion between them.

It appears to me indeed that Professor Ramsay's succession of events singularly harmonizes with Mr. W. Hopkins' theoretical views. The first great glaciers might be the consequence of the first abstraction of the gulf stream and setting in of the cold northern current; the land might then be gradually depressed till it was lowered 2300 feet below its present level, and thus get too low for the formation of glaciers, though its shores might still be incumbered by winter ice; it might then have been gradually elevated again till its summits became re-covered by perpetual snow, and glaciers again formed, which would in some cases plough channels in the incohærent drift. Many similar oscillations of level, and changes in local conditions, might have taken place within the glacial period, caused by the reversal of the oceanic currents.

As an interesting paper in connexion with such part of the drift as can have been produced by great currents, I wish to direct your attention to Mr. Prestwich's account of the "Effects of the Holmfrith Flood," describing the circumstances under which it occurred, and the power it exerted in the transport of heavy materials. Any one who would send to us a similarly accurate and detailed account of the effects of the floods in the rivers Lee and Blackwater, and in other parts of the south-west of Ireland during the last autumn, would be doing good service to our science.

I may here also notice that in Professor Nicoll's Paper on the "Geology of Cantyre, Argyleshire," he describes the drift of that peninsula, and also an interesting example of the raised beach, about 30 feet above the present level of the sea, so well known on the west coast of Scotland. In one part of Cantyre is a long ledge at this height, beneath a precipitous cliff of very hard porphyry, in which is a line of caverns, stretching in even 130 feet into the rock, their floor covered by boulders and shingle, by whose agency the former breakers excavated the caverns. Professor Nicoll remarks on the long period of time during which the land must have been stationary

at that level, for the erosive action of the sea to have produced such an effect on so unyielding a material, and that the period must greatly have exceeded that which has elapsed since the elevation of the land to its present level.

Space will not allow me to do more than direct your attention to Dr. P. C. Sutherland's Notes on the "Geological and Glacial Phenomena of the coasts of Davis's Straits and Baffin's Bay," where an action is now going on through the agency of shore-ice, glaciers, and icebergs, such as we believe to have occurred in our own regions during the existence of the glacial sea. One fact mentioned by him is very remarkable, namely, that while the glaciers are of great size on the coasts of Greenland and Davis's Straits, where the rocks are crystalline, they are comparatively few and unimportant on the upper Silurian tracts in the neighbourhood of Prince Regent's inlet. It appears that although the mean annual temperature is lower in the latter than the former, yet the summer heat is greater, and is therefore sufficient to melt the winter's snow and ice, and cause it to run off in water instead of accumulating into glaciers.

I would also recommend to your notice the Paper by Mr. Morris on some railway "Sections in Lincolnshire," where he gives some very curious details of the "drift" of that locality.

Mr. Trimmer's Papers on the "Erratic Tertiaries," and on the "Gravels of Kent," form part of a series of very elaborate investigations, entering into much minute detail from which we may ultimately derive results of great value, but of which it would be impossible for me to give you even an abstract with the space at my disposal.

One circumstance which occurs in nearly all these descriptions of English drift, as particularly in one by the Rev. H. M. De la Condamine on that of Huntingdonshire, is the occurrence in it of freshwater beds with freshwater and land shells.

This is a part of the drift subject which more especially requires working out in Ireland; and from devotion to which there is little doubt that good results would arise if any of our more active members would take it up.

I have been led insensibly by the discussion of Mr. Hopkins's paper to enter more largely on the subject of "Drift," than I at first intended. I will close it by one observation, namely, that we in Western Europe are in danger of being insensibly biassed by the

very prominent action of the conditions of the glacial sea, to attribute to them more than is justly their due. We must recollect that "Drift," meaning by that term superficial accumulations of clay, sand, and gravel, often of great thickness and extent, and composed of fragments of respectable weight and dimensions, is not confined to the region of the glacial sea of Western Europe, but occurs in almost all countries, in nearly all latitudes. I have only to remind you of the thick auriferous deposits of Australia, where beds of consolidated gravel interstratified with sand and clay, 60 or 70, or even, if recent accounts are true, as much as 150 feet thick at least, occur over very large tracts, containing great blocks of quartz, weighted with gold up to more than a hundred-weight, to show that glacial conditions are not absolutely necessary for the transport of very considerable masses, some distance from their parent site.

In the Journal of the Geological Society of London for May, 1853, there is a very good descriptive paper on the gold-fields of Victoria or Port Philip, by Mr. G. H. Wathen, Mining Engineer. He gives a general description of the structural features of the country, as well as of the auriferous drift. In speaking of the latter, he mentions boulders of quartz, two or three feet in diameter, as embedded in the "pipe-clay."

My friend and former colleague, Mr. Alfred R. C. Selwyn, now Director of the Geological Survey of Victoria, writes me word that he has at present reason to believe that this auriferous drift of Australia is of older date than the volcanic deposits of heavy hornblendic or augitic lava or trap, that form such conspicuous features in the geology of Victoria. He says that he has never seen a pebble of those traps or lavas, in the drift of that country, and never observed any of the drift resting on the lava; while he has reason to believe in some instances that the lava rests upon the drift. The clearing up of this point will be one of the many interesting results we may expect from that gentleman's survey of the colony.*

Having been led to commence with the subject of drift, I will

* Since the above was written, I have had the advantage of perusing Dr. Hooker's most interesting Travels in the Himalayahs, and have, among other things, been greatly struck with the proofs he there gives us of a former much greater intensity of glacial action, even there also, than exists at the present day. Although it may not be impossible to imagine changes in the configuration of land and sea sufficient

throw the remainder of my observations into geological sequence, commencing with

THE TERTIARY ROCKS.

There is a paper of local interest in the London Geological Journal for 1852, by J. Brown, Esq., on the "Upper Tertiaries at Copford, Essex," chiefly descriptive of some beds of brick earth, apparently lying above the drift, and containing bones of bears and beavers, with land and fresh-water mollusca, of which two are of extinct species.

In the same volume we have a very elaborate and critical paper by Sir C. Lyell, on the "Tertiary Strata of Belgium and French Flanders." This paper is full of minute detail, with descriptions of the structure of many localities, and complete tables of fossils, and other valuable matter, making it a great paper for future reference, but not allowing of the process of condensation or abstraction. It is an account of the whole tertiary series of the countries named, and an identification of their several portions with the contemporaneous strata of England.

We have likewise a paper on the "Thanet Sands," or the bottom bed of the English eocene tertiaries, which forms part of a very elaborate and long-continued investigation by Mr. Prestwich into the exact structure and relations of the lower eocene rocks of Britain. The series of papers of which this forms a part is of the greatest value, the result of great labour extended through many years in such intervals of business as may occur in the life of a London merchant, and shows us how much may be done by steady perseverance and determination, even where circumstances seem most adverse to it.

In the Geological Journal for 1853, we have first a paper by J. Motley, Esq., on the Geology of Labuan, more especially descriptive of the coal formation there, which is evidently altogether of tertiary age. He gives a section of about 300 feet thick of alternations of clay or shale and sandstone, with several small seams of

to account for this, yet it is not easy to see why these changes should always have been such as to produce *greater cold* at a particular period of the earth's history, and that over a space so widely separated and so differently placed as Western Europe and Southern Asia. Such phenomena seem certainly rather in favour of the hypothesis of a general lowering of the temperature of the whole globe at this period.

coal, and one having a thickness of 11 feet. This coal is composed of slightly compressed trunks of trees crossing each other at all angles; these trunks are of dicotyledonous wood, and very similar to the trees now growing on the island, with lumps of resin of exactly similar character to that which they produce. In one bed of blue clay, stems of dicotyledonous trees, and occasionally of palms, are found upright and silicified. Large boulders of coal often occur, sometimes in regular layers, and some coarse conglomerates of quartz, sandstones, and coal pebbles. In some of the clays are marine fossils of such existing genera as Tridacna, Tellina, Murex, Pyrula, Oliva, Cerithium, Fusus, as well as others. The beds are inclined at angles varying from 25° to 70°, and similar beds near Bruni are absolutely perpendicular.

I must also call your attention to a very interesting paper by Major Vicary, of Wexford, on the structure of a portion of the "Himalayah range near Subathoo." It must be highly satisfactory to us to see so many officers of the army and navy making use of their opportunities to contribute to the advancement of our science, and by their observations, often hastily made in the intervals between sterner duties, thus enabling us to link together scattered information, and harmonize our knowledge of these distant regions.

The more detailed information we may hope ultimately to receive from my distinguished predecessor on the Survey, and your former President, Professor Oldham, will thus be capable of extension over a much wider district than he will probably be able to visit either personally or by means of his two able assistants, Messrs. J. G. and H. B. Medlicott, both members of this Society.

Of other Indian papers I have only space to mention the titles, as follows:—

Dr. Fleming on the Salt Range of the Punjaub.

Dr. A. Fleming on the Geology of part of the Sooliman Range.

Mr. H. B. E. Frere on the Geology of a part of Sind.

Dr. F. L. Bell's further Account of the Boring at Rotah, Deccan; and a Notice of an Ichthyolite from that place.

The above remarks will likewise apply to Colonel Heneken's paper on the "Tertiary Deposits in San Domingo." From this paper, and the abundant collection of fossils that accompanied it, it appears that that island is largely composed of tertiary rocks of eocene age, presenting the nearest analogies, as a group, to those of

Malta and Bourdeaux in Europe, and South Carolina in America; and that of the 8 or 9 per cent. of living forms that they contain, the majority are living in the adjoining seas; while many have a strong resemblance to, and one or two are identical with, shells now living in the Indian and Pacific Oceans. They thus seem to point to a time when the connecting land between North and South America did not exist, or was to have been found to the east of its present situation. We are almost tempted to ask, can the present curved line of the West India Islands have any relation to the line of some ancient coast, and the Carribbean Sea have been in those days a bay of the Pacific instead of one of the Atlantic, as it is now?

The most important and interesting paper, however, on tertiary rocks, published during the year 1853, is that by my friend and colleague, Professor Edward Forbes, now President of the Geological Society of London. We may be allowed, perhaps, to claim it as one of the advantages of a Goverment Geological Survey, in a scientific point of view, that, as we examine all districts indifferently in an equally detailed manner, we now and then are likely to come upon new facts in places, the structure of which has hitherto been taken for granted as sufficiently known, and therefore not critically examined. When Professor Forbes came, in the course of his duties on the Survey, to examine the fossil localities of the northern part of the Isle of Wight, he found so much that was not only palæontologically but geologically new, that he was obliged, even with the able assistance of several other officers of the Survey, to devote four months of constant and daily labour to its examination.

You are aware that it had been hitherto supposed that, while the lower and middle portions of the eocene system were fully represented in England, there was a total absence of all the upper portion of that series. The highest English eocene beds were believed to be only on a parallel with the upper part of the *calcaire grossier* of the Paris basin, and we were supposed to have no equivalents of the well-known gypsum beds of Montmartre, or the lower freshwat stone and its superincumbent beds. The new researches of sor Forbes prove that we have in the northern part of the Wight the exact palæontological equivalents, with well- lithological characters, of even the highest beds of the Paris and of beds that are probably even higher than any there ; the Rupelian, or Upper Limburg beds of Belgium.

Professor Forbes shows that those beds which have been hitherto lumped together as Headon beds are capable of a threefold subdivision, into what he terms, the Saint Helens' beds as the lowest,—the Bembridge series as the middle,—and the Hempstead series as the highest. The two latter are themselves again capable each of a threefold or fourfold division into "stages," characterized by peculiar fossils. Characteristic fossils of these groups are now deposited in the British tertiary cases in the palæontological galleries of the Museum of Irish Industry, where they are open to your inspection and study.

This discovery is very important, first as showing that Great Britain has the most complete series known of the eocene tertiaries, as she has of the secondary rocks, and has them in immediate connexion and direct order of superposition; and secondly, as giving us a key to the classification of large districts of the Continent, where widely-spread and important beds must now be referred for their nomenclature to a few little spots in the northern part of the Isle of Wight. It will indeed introduce important changes in the colouring of the Geological Map of Europe.

SECONDARY ROCKS.

Although there are several papers in the two last volumes of the London Geological Journal on minor and local points in secondary geology, doing great credit to their authors, and contributing facts highly worthy to be known to the great body of geological science, there are none of sufficient general interest, or at least of sufficient interest to us in this country, to warrant me in taking up your time by giving any account of them.

In our own Journal the only paper on secondary geology is one by J. B. Doyle, Esq., entitled, "Notes on the Salt Mines at Duncrue, and Searches for Coal by the Marquess of Downshire." The details of the sinkings given in this paper are valuable as records, and the section gives a good general idea of the structure of the neighbouring district. There is, however, no mention made of the lias, a thin band of which I observed when examining this district in company with the Marquess of Downshire in 1852, just at the top of the red marl. The conformability of the beds mentioned by Mr. Doyle of course gives us no assurance of the same structure continuing below the beds examined, and the place where unconforma-

bility is most to be dreaded is at the base of the new red sandstone series, which is as likely to rest upon any of the inferior rocks as upon a productive portion of the coal-measures.

PRIMARY OR PALÆOZOIC ROCKS.

Of this portion of the geological series we have several papers, of great interest and importance, in the Geological Journals for 1852 and 1853. In the first place, we have three papers by my beloved old master and geological father, Professor Sedgwick, on the palæozoic rocks of Devon, North Wales, and Cumberland, giving additional descriptions of the structure of those countries, in his usual graphic and masterly style. He has, however, another paper of still higher importance, as bearing more directly on the general classification of the palæozoic rocks, namely, the one "On the proposed Separation of the so-called Caradoc Sandstone into two distinct Groups, viz.:—1. May-Hill Sandstone; 2. Caradoc Sandstone." Professor Sedgwick proves, what had also been recognised by the Geological Survey, that under the name of Caradoc sandstone two distinct sets of beds have been confounded. This has happened from the fact of two sandstones coming together of somewhat similar mineral character, although containing distinct fossils. In consequence of their similarity in mineral character, and their reposing directly one on the other, the fossils had been mingled together,* and thus quoted as from one group, while in fact those from the upper beds were different from those in the lower; the first belonging to the Wenlock type, and being therefore upper Silurian; and the latter having much more of the Bala aspect, and belonging, therefore, to the lower Silurian. Even in the true typical Caradoc country in Shropshire, these two sandstones have been subsequently separated by the Survey, inasmuch as not only were their fossils distinct, but the upper group was found to repose unconformably on the lower.† Professor Sedgwick justly points out that this separation which he introduces between rocks that had hitherto been confounded un-

* It was this mingling of character which led me, in a little work called "Popular Physical Geology," published last year, to speak of the Caradoc sandstone as "middle Silurian."

† See the paper by J. W. Salter and W. P. Aveline, "On the Caradoc Sandstone of Shropshire," in the first part of the London Geological Journal for 1854, which has appeared since this was written.

der one name likewise introduces a sharper and more distinct line of boundary between those two great formations which have been hitherto known as upper and lower Silurian, but which he would now call Silurian and Cambrian. I think it very likely that he is right in another point also, namely, that the Merioneth and Denbighshire Caradoc of the Geological Survey Maps belongs rather to the base of the Wenlock than to the true Caradoc sandstone; that it is a local thickening of the sandy beds of the lower part of the Wenlock shale as they approach the trappean hills on the west. I also think it probable that the true Caradoc sandstone is only a similar local thickening and passage into sandstone of the upper portion of the Bala beds as they travel towards the east. There is, however, distinctly no unconformity—except, perhaps, in one very small locality—in the position of the beds of the upper and lower Silurian formations in North Wales; as the upper Silurian—whether called Caradoc sandstone or Wenlock shale—rests on the same thin group of "*pale slates*," forming the top of the Bala beds from Mallwyd to Conway in one direction, and to Llangollen and Bwlch Rhiw Felyn in the other.*

I will just here say one word as to the controversy respecting the terms "lower Silurian" and "Cambrian." It resolves itself into a question of whether we should take palæontological or lithological and stratigraphical characters as the foundation of our classification. Every one—including Professor Sedgwick and Sir Roderick Murchison—used to think that the rocks and fossils of Caernarvonshire and the neighbouring parts of North Wales would of necessity be all older than those of Montgomeryshire, Shropshire, and the Welsh border country. The Silurian rocks and fossils, therefore, with their subdivision into upper and lower, were *accepted* as one thing; and the Cambrian rocks and fossils were *expected to turn out* another thing when the latter came to be fully

* It seems pretty clear, then, that the term "Caradoc sandstone," as designating an independent formation, having peculiar lithological and palæontological characters, must disappear. Whether the term should be applied to the sandy beds at the base of the Wenlock shale, or to the similar sandy beds at the top of the Llandeilo and Bala formation, remains to be decided. I should myself prefer to keep the term as representing a local group at the top of the lower Silurian, and to adopt Professor Sedgwick's name of "May-Hill sandstone" or "Wenlock grits" for the base of the upper Silurian.

described. Instead of that, it results that what were called the lower Silurian rocks on the Welsh border, and which were left with a totally undefined base, had really a much greater thickness than was expected, and swept in many broad folds and undulations through the whole of North Wales; and that the rocks of Siluria, with the exception of the uppermost, were the same as those of Cambria. In Cambria, however, the rocks only were described, while in Siluria both the rocks and fossils were described and figured; neither, indeed, completely, but both so much so that the contemporaneous rocks of other countries could be recognised by their fossil characteristics. Had the identity of the rocks of Cambria and Siluria been known at the time, it is probable that only the upper would have been called Silurian, and the lower would have been christened Cambrian. It was not so known or understood, however, and it has now, I believe, become practically impossible to remedy the mistake, if it be one, and to persuade men to call those things Cambrian which they have always been in the habit of calling Silurian, although no one will be more ready than myself to adopt the change of nomenclature, should it be generally decided on. The only way to bring such a correction into use would be to adopt a middle term, and to speak of the lower Silurian as Cambro-Silurian.

I would here remark, also, that the conformity which appears in North Wales between these Cambro or lower Silurian rocks and those below them, and which enables them, therefore, to be grouped as upper and lower Cambrian, has been now, as you are aware, shown not to exist in this country. The paper submitted to you by Mr. Wyley and myself proves an utter discordance and the widest unconformability possible, between the great lower Silurian formation of black slate and that equally large mass of green and red slates and grits of the county of Wicklow, which, by every lithological evidence is identical with the Barmouth and Harlech, or the Llanberris and Penrhyn group of North Wales, to which the term Cambrian has been applied by the Survey. If that identity be admitted, it is scarcely possible to include under the same name the upper and lower rock groups of Caernarvonshire and Merionethshire. It is clearly impossible to do so in Wicklow; I am, therefore, on the whole, for the sake of convenience alone, inclined to retain the name of lower Silurian, however otherwise inappropriate it might be

shown to be, and to restrict the term Cambrian to these lower group of rocks in North Wales, Ireland, and the Lake District; and I say this reluctantly, and in spite of my natural feeling, which would lead me to back the opinions of Professor Sedgwick against all the rest of the geological world.*

The paper to which I have just alluded contains two principal points:—1st. That the so-called lower Silurian rocks repose quite unconformably on the edges of the beds of a very low portion of the Cambrian series. 2ndly. That no portion of the Cambrian series is seen anywhere to repose directly on the flanks of the granite hills, the granite having come up through the Silurian rocks, which, for a certain space, *dip towards the granite*, having merely the edges of their beds turned up against it, directly on the flanks of the granite hills.

The paper likewise gave a sketch of the general relations of the quartz rocks to the slate beds; a subject which has been treated of more largely by Mr. Kelly, in his paper "On the Quartz Rocks of the northern part of the County of Wicklow." Mr. Kelly's paper is a valuable and interesting one, as must every paper be that is the result of fair, honest, hard work and observation in the field. I believe, however, that its value is deteriorated by many of the observations having been made after the hypothesis was formed which they are held to support. If I am wrong in this, I hope Mr. Kelly will pardon me; but I believe that in some of his sketches and diagrams representing particular localities, the actual data observed have been connected and extended in such a way as to support the hypothesis, when they might with equal propriety have been so drawn as to give a different interpretation to the facts. I allude more particularly to the maps where the quartz rocks have been connected and extended over spaces where no rock can be seen, and where slate may exist with equal probability; and to the diagrams on pp. 249, 251, and 252, where the lines marking the bedding of the slate are, I believe, not strictly accurate, or, perhaps, represent partly bedding and partly cleavage lines. In the diagram

* If we do away with the term lower Silurian, and replace it by Cambrian, it will be necessary to invent some other term to designate the green and red grits and slates of Caernarvon and Merioneth, on one side of the Channel, and Wicklow and Wexford on the other, which in each country are the lowest visible stratified rocks.

on p. 249, the non-extension of the two little slate beds into the quartz rock is obviously quite a gratuitous supposition, and therefore the extension and connexion of the mass of the quartz rock below is equally hypothetical.

In two other diagrams, as that on p. 250, the abutting of the slate rocks against the quartz rocks is, I believe, produced by small faults. In the large diagram on p. 255, I have little doubt of the features of the quartz rock being quite correct, and think that only a little irregularity is requisite to be introduced into the slate beds to make it a true picture of nature, and one of which many examples might be found among irregularly bedded and contorted rocks of all descriptions.

Mr. Kelly's hypothesis is, "that the great masses of quartz rock now brought in this locality to the surface were once joined to and formed part of a regular system of stratified quartz rock lying below the gray slaty rocks; that they were in this position rendered semifluid or plastic by subterranean heat, and protruded through enormous fissures made in the overlying grewacke by volcanic or other expansive power from below." After an attentive examination of the district, Mr. Wyley and I came to the conclusion that there was nothing in the structure of the country inconsistent with the received opinion of the quartz rocks here, as elsewhere, being altered sandstone (whether baked or steam-boiled), deposited originally in very irregular beds, often suddenly thickening or thinning out, and ending sometimes very abruptly, interstratified with shales or slates and other sandstones still unaltered, the whole having been subsequently disturbed and enormously contorted, perhaps by successive actions of disturbance at different periods. These disturbances seem sometimes to have almost twisted the beds into "true lovers' knots," or other fantastic devices; and as these contorted beds have likewise been broken through by faults and very irregularly denuded, and are now often very imperfectly shown, they must necessarily, in some places, be very mysterious and unintelligible in their appearances.

While on the subject of quartz rock, I would particularly call your attention to a paper by Mr. D. Sharpe, in the eighth volume of the Geological Journal, on the quartz rocks of Scotland. He shows a very large portion of the quartz rocks of that country, which are interstratified with beds of limestone and thin beds of

schist, to be really integral portions of the old red sandstone. This paper is followed by another interesting paper by the same author, on the "Southern Borders of the Highlands." Mr. Sharpe has recently been engaged, at the request of the Geological Society of London, in correcting and revising M'Culloch's Geological Map of Scotland, and has produced and presented to that Society what is, I believe, quite the nearest approximation to an accurate map of that country which we possess.

In the Philosophical Transactions for 1852 is a paper by Mr. D. Sharpe, "On the Arrangement of the Foliation and Cleavage of the Rocks of the North of Scotland." In this paper the author first connects the phenomena of cleavage and foliation, and looks on them as passing into each other, and then describes those of the Highlands of Scotland as parts of planes forming a series of great arches, often of many miles in radius; the cleavage or foliation planes being perpendicular at what may be called the piers or abutments, and bending over at the crowns of the arches.

The paper, like all Mr. Sharpe's productions, is characterized by great ingenuity and clearness of statement; but whether its conclusions are based on a sufficient number of accurate observations still remains a doubt upon my mind. Perhaps no country is more thoroughly "cleaved" than the south of Ireland, where every formation up to the mountain limestone, and I believe the coal-measures, is affected by it. So far as I have at present observed, the phenomena of cleavage here lend no support to Mr. Sharpe's views. From Bray Head to Bantry Bay the cleavage strikes in one general direction, varying only from E. and W. to E. 25° N. and W. 25° S. It almost constantly approaches so closely to a vertical position that the deviation is within the errors of observation, or the amounts of its own local variation; but when it does decidedly incline from the vertical, I believe that inclination is almost invariably to the north, never at a less angle than 60°. More extended observations on this point, however, are yet needed.

The Duke of Argyle has a paper in the ninth volume of the Geological Journal, which is of great general interest, and to me peculiarly so, as tending to confirm ideas long loosely floating in my mind, and which this last summer acquired more precision from my examination of the county of Wicklow. The general notion, I think, with respect to the action of granite is, that it is the grand

disturbing and elevating agent forming the axis of mountain chains, having the lowest of their rocks reposing on its flanks, with successively higher rocks dipping on each side from that central axis. I by no means intend to deny that this structure does occur, though I have myself never seen an instance of it, but I have long had great doubts of its being a necessary, or even a general, occurrence. I have never felt any inclination to attribute any *elevation* or *disturbance* of beds to the intrusive action of any igneous rock, from granite down to lava; on the contrary, I have always been more inclined to look on the outburst of any igneous rock as giving local relief to the intensity of the disturbing force, and as, therefore, mitigating and diminishing the amount of disturbance in the neighbourhood of it. Of course I do not speak of any minor crumpling or dog-earing of the ends of the beds in actual contact with the igneous rock.

The Duke of Argyle, in his paper on the "Granite District of Inverary," describes the great gneiss and mica schist formation of Argyleshire as bent into a broad anticlinal arch between the valleys of the Clyde and Loch Fyne, the beds dipping S. E. and N. W. towards these valleys respectively. In the centre of this anticlinal arch, and along the line of the axis of elevation, there is no appearance of any outburst of granite or other igneous rock, while on the north-western side of the district, between the valleys of Loch Awe and Loch Fyne, where the rocks all dip steadily to the N. W., are great outbursts of granite. The Duke of Argyle describes these as apparently interstratified with the mica schists. Not being acquainted with the country, I can offer no opinion on that point, or how far the facts of the case bear out his Grace's hypothesis of the mica schist at the period of disturbance having "fallen in," as he expresses it, and huge sheets of granite being then injected between the beds, so as to produce the appearance of interstratification. I would, however, just point out to you the analogy between the above facts and those which I described as existing in the structure of the county of Wicklow. There the granite range, although of great size and extent compared with the stratified rocks, and though clearly subsequent to them, as shown by the alteration it has produced on them, and the abundance of veins it sends into them, yet is not the geological axis of the district; on the contrary, the main areas of elevation, as shown by the occurrence at the sur-

face of the lowest rocks, are removed from the granite, which cuts up through the higher rocks, and moreover traverses them obliquely to all appearance, so as to cut different beds in one part from what it does at another. Moreover, along a band of country a little removed from the granite the beds plunge headlong towards it, on each side of it; a fact which suggested to me the idea of their having "fallen into a cavity" left void, as it were, by the intrusion of the granite upwards, though there is no appearance of any injection of granite along the line of this "falling in."*

Before leaving Scotland I will briefly call your attention to a very excellent paper, by Professor Nicoll (formerly of Cork, now of Aberdeen), on the "Geology of the Southern Portion of the Peninsula of Cantyre," which I have already had occasion to allude to when speaking of drift. He corrects M'Culloch's map of the palæozoic and igneous rocks of that district. There are also two sound descriptive papers on the Silurian rocks of the south of Scotland, by Professor Harkness, now of Queen's College, Cork, which give us much valuable and wanted information.

You will hardly need any indication from me of the great interest atached to Mr. Logan's paper on the foot-tracks in the Postdam sandstone in the neighbourhood of Montreal, in Canada, and of Professor Owen's discussion of the nature of the animal that caused them. The Potsdam sandstone is, as you are aware, at the base of the Silurian formation of North America, corresponding in age nearly with the oldest of the *black slates* of the county of Wicklow. It was at first thought that the foot-tracks were caused by animals of the reptilian or batrachian class; a fact, had it been warranted, calculated to have excited great interest. Professor Owen, however, by one of those close, detailed, and exhaustive processes of reasoning from minute indications, and by that application of his vast and profound knowledge to render luminous facts apparently obscure, which have deservedly procured for him the name of the English Cuvier, has shown that the animal that made these tracks was a crustacean, and he points to the present limulus, or kingcrab, as its most probable analogue.

* It will of course be understood that I keep in mind the undoubted fact *of all* these operations having taken place under a vast thickness of Silurian rock which is now denuded. But for this covering the granite could never have cooled as granite.

Dr. Bigsby has two papers on the geology of portions of Canada: one on the neighbourhood of Quebec, the other on the more remote district of the Lake of the Woods. Both contain valuable contributions to our geological knowledge.

Space will not allow me to do more than give you the titles of several other papers on palæontological points connected with the lower palæozoic rocks. These are:—

1. By my late lamented friend, Mr. Hugh E. Strickland, one of the martyrs of our science,—"On the Distribution and Organic Contents of the Ludlow Bone-Bed in the Districts of Woolhope and May-Hill; with a Note by Dr. Hooker on the Seed-like Bodies found in it."

2. By Professor M'Coy, of Belfast,—"On the supposed Fish Remains, figured on Plate 4 of the Silurian System."

3. By Sir R. I. Murchison,—"On some of the Remains in the Upper Ludlow Rock."

4. By Senhor Carlos Ribeiro,—"On the Carboniferous and Silurian Formations in the neighbourhood of Busaco, in Portugal; with Notes, and a Description of the Animal Remains, by Mr. D. Sharpe, Mr. J. W. Salter, and Mr. T. Rupert Jones; and an Account of the Vegetable Remains, by Mr. C. J. F. Bunbury."

5. By Mr. J. W. Salter,—"On Arctic Silurian Fossils."

I must, however, before quitting the Silurian rocks, commend to your attention the very careful paper, printed in the last Part of our Journal, by Mr. H. B. Medlicott, on the Geology of Portraine, county of Dublin. In this paper as good a description is given of the structure of the district as could well be formed from the scanty materials to be found in it. I should be glad to see some of our junior members contributing similar papers to our meetings.

We have several instructive papers on the structure of the upper palæozoic rocks, some of which have been brought before ourselves, some before the Geological Society of London.

The point on which we have still the greatest difficulty is on the rocks which form the connecting link between the upper Silurian and lower carboniferous rocks; in other words, on the Devonian series. The old red sandstone is for the most part the monument of a destructive rather than of a productive action. It shows great forces of denudation and erosion to have been at work on the previously existing rocks, and is itself, therefore, little to be

trusted for a history of the succession of organic life, or of the gradual production of earthy matter under conditions of tranquillity. Wherever such rocks occur they are the indications of a great break and of an immense lapse of time, during which regularly deposited rocks, with regular series of organic remains, must have been in course of formation somewhere.

In order to carry on our geological history properly, we ought to throw aside the first, and attend solely, or nearly so, to the evidences afforded by the latter, when we can discover them. For this reason, every attempt to put into proper co-ordination the series of Devonian rocks is deserving of our careful attention, and among these I would place in the foremost rank a paper by Mr. Daniel Sharpe, entitled, "A Review of the Classification of the Palæozoic Formations adopted by M. Dumont for the Geological Map of Belgium."

M. Dumont throws the whole of the palæozoic rocks of Belgium —from the coal-measures down to the upper Silurian, inclusive— into two great groups, which he calls Terrain Anthraxifere and Terrain Rhenane. Each of these two "terrains" are divided into three "systems," as in the following Table:—

Terrain Anthraxifere.	Coal measure system,		1. Sandstones, shales, and coal.
	Condrusian system,	Calcareous,	2. Crinoidal limestone, dolomite, limestone with productus, chert, and anthracite.
		Arenaceo-schistose,	3. Sandstones with anthracite. 4. Gray shale, calcareous shale, limestone, and oolitic "oligiste."
	Eifelian system,	Calcareous,	5. Limestone and dolomite.
		Arenaceo-schistose,	6. Gray fossiliferous shale, calcareous shale, and argillaceous limestone, oolitic "oligiste." 7. Red conglomerate, sandstone, and shale.
Terrain Rhenane.	Ahrian system,		8. Bluish-gray grits, sandstones, and shales.
	Coblentzian system,		9. Bluish-gray grits and flags.
	Gedinnian system,		10. Greenish-gray conglomerates, and red and green flags.

Mr. Sharpe dissects and readjusts this classification, co-ordinating it with our British classification, and putting it into English nomenclature, as follows:—

Belgian.	Lithological Description.	English.	
Coal-measure system, ...	1. Sandstone, shale, and coal,	Coal-measures.	Carboniferous series.
Condrusian system,	2. Crinoidal limestone, &c. . .	Upper carboniferous limestone.	
	3. Sandstone with anthracite, .	Carboniferous sandstone of N. of England.	
	4. Gray shale, limestone, &c.,	Lower carboniferous limestone; lower limestone shale of Northumberland and Scotland; culm measures of Devonshire, including Petherwin and Pilton beds.	
Eifelian system, . .	5. Limestone of Eifel, ...	Limestone of South Devon.	Devonian series.
	6. Gray fossiliferous shale, &c.,	Shales and schists below ditto.	
	7. Red conglomerate, &c., . .	Old red sandstone.	Old red or Rhenane series.
Ahrian system, . .	8. Bluish-gray grits, sandstones, and shales, . . .	Ilfracombe and Linton series and sandstones S. of Plymouth.	
Coblentzian system,	9. Bluish-gray grits and flags.	To be sought for in south of Cornwall.	
Gedinnian system, .	10. Greenish-gray conglomerates and red and green flags, .	Tilestones of Upper Ludlow.	Silurian.

On this classification of Mr. Sharpe's I should wish to say a few words. First of all, I do not know on what accurately ascertained grounds he separates the carboniferous limestone of the north of England into an upper and a lower, with an intermediate group of coal-bearing sandstones, between them. My own belief is, that the upper portion of the mountain limestone of Derbyshire becomes split up towards the north by beds of shale and sandstone, the limestone gradually dying out and beds of coal coming in, and that this gradual change of type is continued deeper and deeper into the formation the farther we go north, until eventually, in Scotland, the carboniferous system consists throughout of coal-measures, with some comparatively unimportant beds of limestone (only two, of 20 or 30 feet each, near Edinburgh), and that these coal-measures at the base of the system, resting directly on the old red sandstone, are the representatives of the mountain limestone, and not of the

coal-measures, of south and central England. I believe, also, that it will ultimately be found that a similar change in the lithological character of the carboniferous series takes place in Ireland; that, for instance, the Ballycastle coal-field is low down *in* the mountain limestone, and perhaps at the bottom of it; in corroboration of which idea Mr. Ormerod, of Manchester, informs me that in the upper part of that small coal-field he observed, not long ago, a band of limestone full of Productæ. With such great changes of type within our own islands, therefore, any minute identification of parts of the Belgian with parts of our own series becomes to the last degree rash and dangerous.

If, however, Mr. Sharpe wished to identify Group 4 with any portion of the carboniferous rock of Britain, it appears to me much more natural and much more safe to go to South Wales instead of to Scotland, and to point to the lower limestone shale, which there underlies the solid carboniferous limestone, as its probable equivalent. He might then carry on those beds into Devonshire, and place them on the horizon of the beds of Pilton and Barnstable, in the north, and of Tintagel and South Petherwin in the south. As to the culm measures of Devon, I should myself be more inclined to look upon them as the equivalents of the culm measures of the south of Ireland, which repose directly on the mountain limestone, and therefore to suppose a gap between those of Devon and the Pilton beds.

I wish, however, to speak with great hesitation as to any portion of Devon, as my knowledge of it is confined to that gained during a visit of a few days only, in company with Professor Sedgwich, in 1841.

Mr. Sharpe identifies Group 7 (the red conglomerate) with our old red sandstone, considering it its entire equivalent; while the two groups just below (8 and 9) are full of Devonian fossils, such as those found in the Eifel limestones above. Any argument drawn merely from variations in thickness in the two parts of the formation would have little weight with me. The old red sandstone of parts of Wexford is not more than 20 or 30 feet thick, while in the western parts of Waterford it is more than 3000.

I think, however, it would be prudent to wait for a little more evidence before considering this identification established. Mr. Sharpe seems to feel a difficulty in supposing that in the same sea two de-

posits were forming at a short distance apart: the one, of red sandstones and conglomerate; the other, of gray schists and limestones; without any interchange of characters between them, or any gradual passage from one into the other. To this we might reply, that as the beds are not continuous, on account of the intervention of the Bristol Channel, there may have been passage beds which are now removed or concealed. Any one who will examine the great beds of red sandstone and conglomerate of the county of Waterford, capped by thick yellow sandstone, on which the mountain limestone rests almost immediately, and will then walk thirty or forty miles along the strike, and see the sandstones passing into shales, and a mass of gray slates, upwards of 6000 feet thick, interposed between the red and yellow beds and the limestone, will be prepared to understand and believe in changes of type quite as great as that which may have taken place between South Wales and Devon.

I am not without hope that to Ireland will be due the honour of setting at rest the *questio vexata* of the exact place, and value, and relations of the Devonian rocks, since in the south-west we have—in addition to this enormous expansion of beds between the mountain limestone and the regular old red sandstone—an equally great expansion of the lower part of the old red sandstone itself, a thickness of many thousand feet of red and green grits, interstratified with blue slates, rising up from below the ordinary old red, in the country between Macroom and Killarney.

When this country comes to be explored by the Geological Survey, we may hope it will yield some organic remains to the labours of our collectors, and thus give us the means of settling the question palæontologically as well as physically.

In connexion with this subject of the classification of the Devonian rocks, I would point out to your attention the papers by Mr. R. A. C. Austen, "On the Series of Upper Palæozoic Rocks in the Boulonnais," in the London Geological Journal; and the paper by Mr. W. S. Willson, entitled, "Notes on the Geology of the southern portion of the County of Cork," in our own Journal.

A local paper was recently laid before us by Mr. Triphook, descriptive of a section from Long Island to Mount Gabriel, in the neighbourhood of Skull, county of Cork, giving us a valuable de-

scription of facts, and indicating powers of observation from which we may hope still more valuable results in future.

On the palæontology of the Devonian Rocks, I find in the London Geological Journal the following papers:—

"Notice of the Discovery of Reptilian Foot-tracks and Remains in the Old Red or Devonian of Moray," by Captain Brickenden.

"A Description of the *Telerpeton Elginense*, a Fossil Reptile recently discovered in the Old Red Sandstone of Moray; with Observations on supposed Fossil Ovas of Batrachians, in the Lower Devonian Strata of Forfarshire," by Dr. Mantell.

"Notice of the Discovery of Fossil Plants in the Shetland Islands," &c., by Hon. H. Tufnell; and,—

"On some Fossil Brachiopoda of Devonian Age, from China," by Mr. T. Davidson.

There are several interesting papers on different portions of the carboniferous series, of which I would speak first of our Secretary's (Professor Haughton) paper "On the Newer Palæozoic Rocks which border the Menai Straits in Carnarvonshire." This paper, as you must have been aware, is a very excellent one in several ways, and as such is deserving of our careful attention and rigid scrutiny. I have no doubt of the accuracy either of the description of facts, or of the theoretical explanation of them, given in the first part of the paper, at the same time I would utter a word of caution on two points:—First, it is necessary, in attempting the explanation of the disturbances that have affected any district, and of the action of any igneous rocks that have been intruded into it, to make allowances for the possible wide differences in the condition that obtained when these effects were produced, from what exist at the present day. For instance: it is quite possible that when the faults and trap dykes were produced in the carboniferous rocks of the Menai Straits, that the rocks which still exist there were covered by a great thickness of other rocks that have since been removed by denudation. Secondly, it appears to me that Professor Haughton lays too much stress, perhaps unintentionally, on the actual intrusive trap as the disturbing agent. It seems to me impossible for any mere dykes of fluid matter, such as are there described, to have exerted any mechanical action of much consequence on the great sheets of solid rock about them. There must have been some great

mechanical force at work under the whole neighbouring district, which, at the time it produced the cracks and disturbances, allowed a passage here and there to some of the molten igneous rock below to insinuate itself into the fissures thus formed. I cannot suppose that the molten rock, while fluid, would in the mere form of a dyke exert lateral pressure sufficient to cause fractures or contortions in the surrounding rocks, though I can fully comprehend—on the supposition of the aqueous rocks having been first arched and fissured, and then penetrated by igneous rock—that that intrusive dyke, when cooled and consolidated, and when the rocks were settling down again, might prevent their occupying the same space as before, and thus cause lateral crumplings or subsequent shifts and dislocations. This modification of Professor Haughton's views would more nearly coincide with my own notions on the subject, though, on a question of pure physics, I should always be ready to rate his authority as of much higher value than my own.

The palæontological portion is worked out in a most careful and praiseworthy manner, and is valuable both as a description of the locality itself, and for the purpose of comparison with our Irish formations. It fully bears out Professor Haughton's conclusions, that there is in the Menai Straits no possibility of dividing the rocks into Carboniferous and Devonian. This, however, I for one should never have thought probable. The yellow sandstone of Dr. Griffith, in the north of Ireland, is undoubtedly part and parcel of the carboniferous formation, and with that the beds of the Menai Straits may very fairly be compared. Whether, however, the yellow sandstone of the south of Ireland be the same thing, or whether it be not a set of beds of similar lithological character, but occupying a much lower horizon, and belonging more properly to the old red sandstone, is another question. From the distinctive character of the fossils at Kiltorkan Hill, in the county of Kilkenny, viz., the *Cyclopteris Hibernicus;* the *Anodon Jukesii* (Forbes); the fossil fish; the *Pterygotus;* and the other plants; and from the two first named having again been found on the same geological horizon, close to the city of Cork,—this question seems likely to be answered in the affirmative. In that case, the carboniferous slate of the county of Cork may possibly turn out to be the transition beds from the Devonian into the carboniferous series.

We have had several minor papers on carboniferous districts

laid before us, of which I must content myself with giving the titles, for want of room to do more:—

1. "Remarks upon the Geology of the vicinity of Ballyshannon;" by R. Crawford, Esq.

2. "Notes on the Geology of the Country about Kingscourt;" by John Hamilton, Esq.

3. "On the Queen's County Collieries;" by Arthur A. Jacob, Esq.

On carboniferous palæontology there is, in the London Geological Journal for 1853, a highly interesting paper, by Sir C. Lyell and Mr. Dawson, "On the Remains of a Reptile (*Dendrerpeton Acadianum*, Wyman and Owen); and of a Land Shell discovered in the interior of an erect Fossil Tree in the Coal-measures of Nova Scotia; with Notes on the Reptilian Remains, by Professor Wyman and Professor Owen." And also one by Professor Owen, "On a Batrachoid Fossil in British Coal Shale." And one by Sir Philip de Malpas Grey Egerton, "On two new Species of Placoid Fishes from the Coal-measures."

In the London Geological Journal for 1853 there is also a paper by J. W. Dawson, Esq., "On the Albert Mine of Hillsboro', New Brunswick."*

This mine has been the occasion of much controversy, both of a scientific and legal character, in America. Mr. Dawson first shows the geological place of the rocks containing the mineral substance of the Albert mine to be at the base of the carboniferous series of that part of the world, "on the geological horizon of a singular band of pseudo coal-measures which occur in several places in Nova Scotia below the great lower carboniferous marine limestones." He then describes the curiously complicated contortions of the rock in which the mineral substance lies, and describes the nature of the substance itself. The controversy was as to whether this substance was a true coal, formed by deposition contemporaneously with the rocks in which it lies; or whether it was of the nature of a mineral vein, the bituminous substance having been subsequently injected or

* In the number of the London Geological Journal for February of this year, received just before sending these sheets to the press, are two papers by this gentleman, on the coal-measures of Nova Scotia, which appear to be of the highest interest and importance, but I have not been able as yet to do more than cast my eye over them, and can only therefore thus briefly point them out to your attention.

transported in some way into a fissure in the rocks. Mr. Dawson inclines to the former opinion; and so far as one may venture a judgment on a locality one has not visited, I am quite inclined to agree with him. From my experience in examining some of the faults affecting the thick coal of South Staffordshire, there seems to be nothing in the physical structure of the rocks of the Albert mine incompatible with the idea of its having been once a regular bed, and having assumed its present condition, and its present relations to the surrounding rocks, in consequence of the action of these forces of disturbance which Mr. Dawson points to. I have seen entanglements of coal and other rocks quite as remarkable as any there described; and we can easily conceive the possibility of even a still greater alteration of structure, compared with ordinary coal, taking place in a substance so easily acted on as coal, and containing so many excitable chemical components; an alteration that might be produced by the impulse of either chemical or mechanical forces.

It is singular that during the past year a case arose in Scotland of a somewhat similar character, in which I happened to be personally concerned. For various reasons I will trespass on your patience with a short account of this.

A dispute arose between the lessor and lessee of a mineral property at Torbane Hill, near Bathgate, Linlithgowshire, as to whether a certain mineral substance was coal or not. This substance occurred in an undoubtedly true bed, interstratified with other beds of the ordinary coal formation, and varying generally from a few inches to nearly two feet in thickness, but sometimes, as I was informed, thinning out altogether. In this respect, then, it did not differ from other beds of coal or other stratified rocks; moreover, all the beds were nearly horizontal, and not at all disturbed. The question raised was, whether it was coal or not; and a trial took place lasting several days, costing a vast expenditure of money, and involving the attendance of seventy or eighty scientific and practical men, many of them of the first eminence in their several pursuits. The evidence as to the chemical and other minuter characters of the substance was most conflicting; and while there was no dispute as to the physical circumstances of its occurrence, the geological opinions given may be stated as the three following:—

1st. That it was coal, although of a peculiar and unusual kind.

2nd. That it was not coal, *but* bituminous shale; the bituminous portion being originally mingled with the earthy matter.

3rd. That it was bituminous clay or shale; the bitumen having been injected into the clay, or in some way introduced into it, *subsequently* to the deposition of the rocks above it.

This latter opinion was inferred rather than directly expressed: it may be at once refuted, if refutation be necessary, by the fact of no true bitumen being now found in the mineral, but only the constituents of which bitumen is formed.

In the second opinion this fact was pointed out; "bituminous" being taken merely in the popular sense as "matter from which bitumen could be obtained." Strictly speaking, then, this should be called "carbonaceous shale." But we may ask, if a "bituminous" or "carbonaceous shale" be so highly inflammable or combustible as to burn freely of itself after merely being lighted, in what respect does it differ from coal?

I do not wish to speak in a merely popular sense, but in a strictly scientific one, to ask, what is coal?

Geologically, coal is not a "mineral," it is a "rock."* It is not a definite chemical compound; it is a mechanical admixture of various substances. These substances are usually vegetable and earthy matter: both the vegetable and earthy matter probably varying in kind, and having every possible variety in proportion.

But it does not appear to me to be absolutely necessary for the production of "coal" that it should contain any vegetable matter at all; since, if there were a sufficient quantity of *animal* and earthy matter to produce the requisite proportion of carbon and hydrogen, in the resulting rock, to emit flame and support combustion on heat being applied to it, I know not how geologists could refuse to call it coal. I believe that some of the Kimmeridge coal, in the lower part of the Kimmeridge clay, derives its carbon and hydrogen from the decomposition of animal rather than vegetable matter. Geologically, then, there is every possible gradation from coal into carbonaceous or bituminous shale; and it is impossible to say where one

* Coal and its allies—"jet," "amber," &c.,—ought to be removed from mineralogical treatises, as not minerals in any true mineralogical sense. They should be considered as either "rocks" or "fossils." A "mineral" ought to have a definite chemical composition and a *definite crystalline form*, as well as certain constant physical characters.

ends and the other begins; the single test, both scientifically and practically, being whether it will "burn" or not.

In the January Number for this year of the Quarterly Journal of Microscopical Science there is a paper by Professor Quekett, "On the Minute Structure of the Boghead Cannel Coal." In this paper Professor Quekett puts forward some views which are at least new to me, if not to geologists in general. He states, that all coal is "fossil wood," and is rarely, if ever, composed of the plants such as Stigmaria, Sigillaria, Lepidodendra, &c., which are found associated with it. He also states his belief that anthracite is "fossil coke;" in which expression, however, he may perhaps use "coke" merely as a synonym for carbon.

Any new discoveries, as to the minute structure of coal in general, made by a man of Professor Quekett's acknowledged eminence, will, I am sure, gentlemen, be received by all geologists with the greatest delight. I would, however, with all respect, venture to ask Professor Quekett not to rest satisfied until he has not only examined many hundred specimens of coal from different localities, but also many which he would find it impossible to procure unless by his own hands in the mines themselves.

Every important seam of coal is made up of two, three, or half a dozen beds, and each bed of a multitude of layers; both the beds and the layers differing widely in character, and, doubtless, in composition. In one part of a compound seam of coal, one bed will be good coal and another worthless, while at a distance of a hundred yards or two they will have altogether interchanged characters. Cannel coals will pass into bright coals; sulphur coals will become pure and fit for use; bituminous coal will pass into anthracite; stone coal into caking coal, or the reverse; and all without any appearance of disturbing agency, or other change in the conditions of the rocks about them. Many coals that are "gotten" and used for manufacturing purposes on the spot are never brought into the general market at all.

Before, therefore, any microscopical or other characters can be established as essential to the existence of coal, all these kinds of coal must be examined in all their minute and local varieties. But even then, supposing that we went to the extreme of proving that all other coals in the world exhibited certain microscopical characters in which the Boghead Cannel was deficient, would that prove it not to be coal? Certainly not; it would merely show it to be a

very peculiar variety of coal, which was *sui generis* so far as those microscopical characters are concerned. For if not coal, what is it? To this the only answer that has been returned is, "bituminous" (i. e. carbonaceous) "shale." To which I reply again, that shale which is sufficiently carbonaceous to support combustion is to all intents and purposes coal. Not that I look upon the Boghead coal as a shale; because one of the essential characters of a shale is an easily fissile lamination, while the Boghead coal is singularly compact, with a conchoidal fracture. It is, in fact, a peculiar variety of Scotch cannel coal.

There are still a few of our papers, gentlemen, not yet noticed. Lord Talbot de Malahide has, on two occasions, laid before us some very interesting fossils from distant countries: once from South Australia, and once from Egypt. Of the latter you will find an account in the last Number of our Journal, entitled, "Notes on the Geology of Egypt."

There are also several papers descriptive of the analysis of certain mineral substances, of which I have only space to give the titles:—

1. "Notes on the Serpentines of Cornwall and Connemara;" by Rev. Professor Haughton.

2. "Account of the Gangue of the Conlig Lead Mine, County of Down;" by Rev. Professor Haughton.

3. "Notice respecting a variety of Magnetic Ire Ore;" by Dr. Apjohn.

4. "On an Analysis of Euclase;" by J. W. Mallet, Esq.

5. "Results of an Analysis of Siliceous Deposits from Hot Volcanic Springs of Taupo, New Zealand;" by J. W. Mallet, Esq.

Lastly, I must mention, much more briefly than it deserves, a paper by our Secretary, Professor Haughton, "On Ballymurtagh Sulphur and Copper Mine;" one apparently of a series that we may expect to receive from him.

In connexion with this I may also call your attention to the recent publication, in the "Records of the School of Mines," of a paper "On the Mines of Wicklow and Wexford," by Mr. Warrington W. Smyth, Mining Geologist to the Survey.

This paper gives an account of the structure of the mineral veins, of the relations that may be traced between their directions, and of the practical working and statistics of the mines. In the latter portion there is a little discrepancy between the Table of the production of the Ballymurtagh mines, as given by Professor

Haughton, and that given to the Survey by Mr. Barnes, the Resident Director. Professor Haughton's Table underrates the production of copper during the eight years closing with 1851, by upwards of 4000 tons, and that of pyrites by more than 2400 tons.

Had this Address not already extended to such an unconscionable length, I should have detailed to you the progress of the Geological Survey of Ireland during the past two years, and have pointed out to you, and through you to the public at large, a plan by which its labours could be made practically useful and beneficial to every one possessed of, or having the management of, landed property. As it is, I can only say that we have now reached Bantry in our progress to the south and west; that the revision of some of the earlier work, for the purpose of publication on the new Inch Sheet Map, and for the compilation of a Report, is begun; and that, generally, we have made as much progress in our work as was possible with the very scanty staff and the very inadequate means that have hitherto been placed at our disposal. On a future occasion I hope to give you something more definite, and announce results of a more gratifying character.

That this Address has reached the length it has is not altogether my fault. My worthy friend and predecessor, Dr. Ball, must be content to share the blame with me, since he has imposed upon me a double task.

There are several subjects and several publications on which I meant to have made remarks, which, for want of space, I am compelled to omit. Among these I would especially mention, the Report on the Geological Survey of Wisconsin, Iowa, and Minnesota, by David Dale Owen, Esq.; and Professor James Forbes's book on Norway and its Glaciers.

The very mention of two such books, so admirably written, so beautifully illustrated and descriptive of the geological structure of countries that even in my early days it would have been considered an actual distinction to a man to have visited, at once brings before our minds, in the most vivid light, the wonderful extension of our science during the last half century. The world at large, gentlemen, may have been regardless of the labours of geologists, and indifferent—as, alas! too many of its inhabitants are—to the wonders and the beauties by which they are surrounded; for many of these wonders and beauties can be seen only through the glass which is held in the hand of Science.

In all parts of the globe, however, we have now, and for many years have had, a band of fellow-labourers, united to us in spirit and in the common interest of a kindred pursuit. It is to societies such as this—as I well know from experience—that many earnest men look for the ultimate appreciation of their labours, when, but for that distant hope, their spirits might perhaps have flagged under the toils, and privations, and dangers to which they have been exposed. If it were for this consideration alone,—namely, in order that we might form one of the central temples in which the sacred torch of Science should be kept alight, to throw a beam of encouragement and approval over the scattered bands of her worshippers in all corners of the earth,—it would be our duty, if it even were not also our pleasure, to use every means in our power to make secure the basis and extend the superstructure of our Society. For such a noble end some little personal sacrifice of time, or of money, or of exertion, is incumbent on us all. Geologists have ever been remarkable, perhaps above every other class of scientific men, for the cordial union, the hearty good fellowship, which has knit them together into a band of brothers. Their contentions and dissensions have almost ever been kept down to mere means of eliciting the spark of truth by the collision of various intellects, or at most have been displays of personal strength and skill, knightly combats in all honour and love, preceded and ended by the cordial shake of the hand, which is the manly habit even of our common pugilists. Much of this good-humour is doubtless owing to the out-of-door and robust nature of our pursuits leading us to take that kind of combined mental and physical exercise most conducive to the production of the *mens sana in corpore sano.* Something, also, is owing to the example set us by the great men who were the founders of our prototype, the Geological Society of London.

Allow me to hope, gentlemen, that along with the scientific and economical benefits which our science has conferred upon the world, it may still remain the boast of Geology that she has contributed her share to this moral benefit also,—that philosophers can differ in opinion without loss of temper, and without loss of respect for their opponents; and that while each is conscious of his own single aim at the discovery of Truth, he is ready to give credit to any one for the same singleness and directness of purpose, who may fancy that she lies in an opposite direction.